

**THE DELPHI TECHNIQUE USED IN LASER INCIDENT SURVEILLANCE**

**A PROJECT REPORT  
SUBMITTED TO THE FACULTY OF  
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**KRYSTYN RACHELLE CLARK, MS  
CAPT, USAF, BSC**

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**PROJECT MENTOR:  
THOMAS JOHNSON, PhD**

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Krystyn R. Clark  
Capt, USAF, BSC  
Department of Preventive Medicine and  
Biometrics  
Uniformed Services University of the Health  
Sciences

## **ABSTRACT**

Title of Thesis: “The Delphi Technique Used in Laser Incident Surveillance”

Author: Capt Krystyn R. Clark

Master of Science in Public Health

Thesis Directed by: Dr. Thomas E. Johnson

Assistant Professor

Department of Preventive Medicine and Biometrics

Surveillance is an important component of trend analysis in laser incident reporting. Proper surveillance of workplaces in which laser systems are used, personnel at risk of exposure and evaluation of laser injuries can lead to better injury prevention and rapid medical treatment of laser injuries that occur. Ultimately, the prevention of laser injuries helps ensure a healthier workforce. Current databases that collect laser incident data were not designed for surveillance of laser incident trends. A laser incident reporting form was created based on a scientific approach for the collection of information about United States Air Force (USAF) laser incident trends, risk factors and injury diagnoses using the Delphi technique. This reporting form was designed also to collect medical evaluation data that could help accelerate the diagnosis and treatment of laser injuries in field conditions.

Four USAF panels were formed from health and safety groups to participate in the Delphi technique: Bioenvironmental Engineers, Health Physicists, Flight Physicians,

and Ophthalmologists. Panel members were selected based on their professional experience with laser systems, medical evaluations and/or incident investigations. The Delphi technique used in this study began with 40 participants completing the first round. A total of 27 people completed all three surveys for 67.5% participation. A list of items that panel members determined to be of value for laser incident trend analysis was submitted during the first two rounds of Delphi surveys. The third round consisted of ranking survey items from the first two rounds for data fields to be included in the laser incident reporting form. Ranked survey responses from panel members resulted in 100 data collection items, grouped by four distinct sections. The four sections of the form included 12 demographic items, 22 laser system items, 24 event information items, and 42 medical information items. Four cognitive interviews were conducted with an individual that met the qualifications of one of the four panels to assess the functionality of the draft laser incident reporting form. Individuals selected for cognitive interviews did not serve as panel members.

The laser incident reporting form developed in this study should be adapted to a database format that allows for data extraction and quantitative analysis of laser injury trends. Further study is needed to determine how the final laser incident reporting form could be incorporated into a central database, or collected concurrently with another agency that studies laser incident data. Analyzing incident trends could be used to better protect at-risk individuals, to minimize risk factors associated with specific laser systems and their application, and to provide the most efficient and effective medical care for injured personnel. The results from analyzing laser incident trends can be used to make informed decisions of where to allocate resources toward laser injury evaluation,

treatment and prevention. A complete laser incident reporting process is essential to maintaining a healthy and productive USAF workforce.

THE DELPHI TECHNIQUE USED IN LASER INCIDENT SURVEILLANCE

BY

CAPT KRYSTYN R. CLARK

Thesis submitted to the Faculty of the Department of Preventive Medicine and  
Biometrics Graduate Program of the Uniformed Services University of the Health  
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## DEDICATION

To my husband, Thomas, for the support and sacrifices you have made during my two years of study. You have been an unwavering source of strength, inspiration and perseverance and I dedicate this thesis to you and our unborn child.

To my mother and father, Duane and Eleanor, thank you for the spiritual and moral values you instilled in me since childhood. Your love and encouragement have served me well in life.



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## **CHAPTER ONE: BACKGROUND**

### **1.1 Overview**

Studying trends in laser incidents is an important public health issue because of the threat of injury to an individual. Laser injuries are relatively new compared to injuries associated with other types of potentially hazardous devices. The first operational laser was produced in 1960 (Barkana and Belkin 2000). Little information is available about the kinds of injuries that have occurred or reasons why they occurred. (Harris, Lincoln et al. 2003). Knowledge of laser injury trends is essential to predicting where injuries will occur and how to prevent them. The need for general guidance in laser incident reporting has been recognized by the Department of Defense (DoD). A DoD policy has been established requiring all three military services (Air Force, Army, and Navy) to report laser incidents to the Tri-Service Laser Radiation Hotline at Brooks City-Base, Texas (Harrington 2004). The Air Force Occupational Safety and Health Standard 48-139 (AFOSHSTD 48-139) is the United States Air Force (USAF) instruction for reporting laser exposures to the Tri-Service Laser Radiation Hotline. DoD laser events are entered into the Laser Accident and Incident Registry (LAIR) through the Tri-Service Laser Radiation Hotline maintained by the U.S. Army. Reports are screened to remove personal identifiers and classified information before entry into LAIR. Not all reported events meet the criteria for inclusion in the LAIR. Classified reports are not eligible for inclusion in the unclassified LAIR database. A report may not be included if insufficient laser event data is provided to the LAIR staff. Some exposures may not be reported through the Hotline because the individual responsible for reporting a laser incident may not be familiar with proper reporting procedures. A more complete system

for collecting consistent incident data is necessary to analyze laser incident trends. The creation of a standard laser incident form is the basic element of a better laser incident data collection system.

## **1.2 Current Air Force Laser Incident Reporting**

In the event of a suspected laser injury per AFOSHSTD 48-139, the USAF active duty member, reservist, civilian or contractor notifies his supervisor of the event and reports immediately to a medical treatment facility for evaluation. The supervisor is responsible for notifying the Unit Commander, Laser Safety Officer or Safety Officer and Bioenvironmental Engineering Services. The Bioenvironmental Engineer must inform the Tri-Service Laser Radiation Hotline at Brooks City-Base within 24 hours of notification of the incident. There is no standard laser incident reporting form to aid the supervisor and Bioenvironmental Engineer in reporting the event.

## **1.3 Limitations of Existing Data**

Laser exposure risks to USAF Personnel have not been scientifically evaluated in the context of past incidents nor has there been a means to effectively characterize past events effectively. A unified database was created in a previous study by compiling six existing laser databases. An analysis of this unified database yielded too few military laser events to evaluate incident trends or to identify characteristics of individuals at risk for laser injury (Keeler 2002). Ideally, laser injury data would be collected and analyzed to develop quantitative estimates of risks to human health from laser exposure under battlefield and routine conditions likely to be encountered by USAF personnel. A limitation of the unified laser injury database was a consequence of the data sources; namely, laser incident data was collected by several agencies for dissimilar purposes.

None of the databases used for this previous study were designed specifically for identifying laser injury trends. Detailed medical information was only collected in one of the databases (LAIR). Another difficulty encountered with these databases was incomplete incident reports. Important information that was essential for trend analysis was missing in each database. A query of the unified database in 2004 resulted in 30 domestic military incident records. As an example, approximately half of the 30 reports did not list state, city, laser wavelength, or age of the individual involved in the incident.

Johnson's study of incidents from 1965 to 2002 yielded 29 military laser injury reports to include 6 Air Force, 15 Army and 8 Navy/Marine Corps personnel (Johnson, Keeler et al. 2003). One study suggested that more laser injuries have occurred, but these injuries have not resulted in USAF lost duty time (Copley, Burnham et al. 2003). This conclusion is supported by a recent study of Army eye injuries that indicated eye injury rates might be greatly underestimated. This underreporting was likely due to selective review of hospitalized cases that overlooked less severe conditions that did not require hospitalization (Wong, Smith et al. 2000). It is difficult to estimate the number of unreported laser incidents. Keeler suspected that some laser injuries were not reported because military personnel feared reprimand, injuries were improperly diagnosed, or incidents were not reported through proper channels (Keeler 2002). A laser user may not be given ample direction for actions that should be taken when a laser event occurs (Barat 2003). Sometimes it is difficult to verify events or acquire additional event details because someone other than the exposed individual reports the event. It may become cumbersome for personnel to follow-up on incomplete reports to acquire all the information necessary for a complete report. Statistical analysis of incident trends could

also be enhanced by inclusion of classified events. The conclusion of examining existing data sources for studying incident trends was that a better system for collecting laser incident data should be developed.

#### **1.4 A New Approach**

A study was undertaken to produce and evaluate a new method of laser incident data collection in a format that could be used for future studies of trends in laser incidents. The need to determine critical data for medical providers and safety personnel in the case of a laser incident resulted in a study to design a laser incident reporting form. The Delphi technique was selected as the most practical instrument for determining what data fields to include in a laser incident reporting form. The Delphi technique is an iterative survey process in which a panel of experts answers open-ended questions to achieve consensus on the identified problem. As defined by Brown,

The Delphi method is a name that has been applied to a technique used for the elicitation of opinions with the object of obtaining a group response of a panel of experts. Delphi replaces direct confrontation and debate by a carefully planned, orderly program of sequential individual interrogations usually conducted by questionnaires (Brown 1968)

This study used the Delphi technique to identify critical laser incident data that should be collected to study laser incident trends based on the opinions of medical and safety experts. This technique has been applied in many different fields, including health and medicine, to reach consensus on complex topics using a systematic method (Schopper, Ammon et al. 2000).

## **CHAPTER TWO: INTRODUCTION**

### **2.1 The Modern Battlefield**

The greatest limitations of using lasers in the battlefield have been power, size, weight, and heat output (Anderberg and Wolbarsht 1992). Progress in laser research has removed many of these technical limitations resulting in smaller, more powerful, portable laser systems, that are currently being used in USAF combat operations (Wong, Seet et al. 1997). Laser eye injuries can cause significant disability and can be quite expensive (both in cost and combat effectiveness) for the DoD, including potential compromise of the military mission. Battlefield uses of laser systems include target designators, communication systems, antiaircraft and antimissile systems, rangefinders, radar and warning systems, and electro-optical sensor destruction (Anderberg and Wolbarsht 1992; Hudson 1998; Barkana and Belkin 2000; Johnson, Keeler et al. 2003).

The military operates in both conventional and unique laser operating environments. Laser hazards in a battlefield setting can result in unique and specialized challenges for protecting USAF personnel. Wolfe states,

The likelihood of laser eye injuries on the battlefield and their capacity to cause acute reduction in vision compels military medical personnel to become familiar with laser-induced injuries and the visual impairments apt to result from them (1985).

An example of a military exposure occurred when the crew of an EC-130 aircraft was exposed to a ground-based laser from a laser light show system located at a casino in Nevada. The laser system temporarily flashblinded the flight engineer (Johnson, Keeler et al. 2003). Keeler's study included fourteen reported incidents from the US Army extracted from the unified database, nine of which were due to target designators or range finders operated during field training (Johnson, Keeler et al. 2003). Laser use in USAF

medical treatment facilities can be another source of inadvertent injury. Currently, lasers are used in many medical applications to include laser vision correction and skin procedures. It is likely that the number of laser applications and laser systems will continue to rise in the military arena. Non-lethal laser technology has been of recent interest for military and law enforcement applications. These systems can be used against personnel for deterrence or targeted against equipment sensors. (Wong, Seet et al. 1997). A need for improved methods of identification, evaluation and prevention of injuries from these various laser systems and applications is vital in protecting USAF personnel.



**Fig. 1.** Low Earth Orbit Position & Reporting Device  
Source: US Army Space & Missile Defense Command



**Fig. 2.** Tactical High Energy Laser  
Source: Air Force Research Laboratory



**Fig. 3.** Airborne Laser System (ABL)  
Source: Air Force Research Laboratory



**Fig. 4.** ZEUS-HLONS  
Source: US Army Space & Missile Defense Command

## **2.2 Laser Vulnerabilities**

In both peacetime and during conflict, the human eyes and skin are the organs of the body at greatest risk for laser injury. An analysis of military and non-military laser incidents from the unified database revealed that eye incidents made up 598 of 1325 reports, or about 45% of all reported laser incidents (Johnson, Keeler et al. 2003). The retina is the major structure of concern for laser injury. Laser damage to the retina may lead to permanent loss of visual acuity or blindness (Wolfe 1985). Keeler noted that a person might experience no pain from a laser injury, meaning that a person may not even know an exposure has occurred (Keeler 2002). Corneal burns can cause intense pain in the exposed individual although this type of injury may have delayed symptoms (Ivan 1999). Laser injuries to the skin can range from mild heating to severe burns. Injury severity is often dependent on the laser pulse width and duration of the exposure. It is important for workers who are at risk of laser exposure to be familiar with common symptoms and know where to seek medical care.

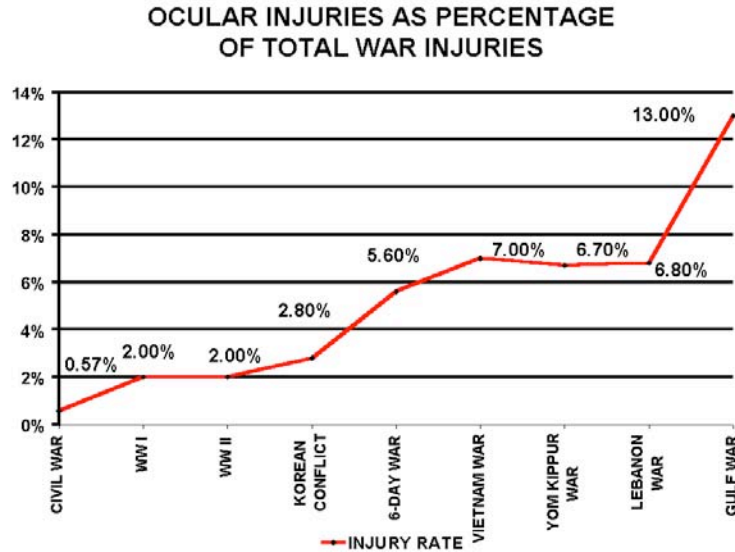
Lasers do not have to cause injury to harm an individual. Even a low-powered laser system miles away from an individual can cause dazzling effects resulting in disorientation (Anderberg and Wolbarsht 1992). Glare, dazzle or flashblinding due to laser energy exposure can result in personal injury or loss of life from secondary hazards during operation of an automobile or aircraft if the exposure occurs at an inopportune time. Even a laser system as commonplace as a laser pointer is capable of causing these temporary visual impairments (Marshall 1999). Personnel in the vicinity of laser operations may be at risk of exposure due to inadvertent exposure even if they are not operating the laser systems. A less severe or unexpected laser exposure may go



unreported because the individual may not be aware that a laser hazard exists. This type of unexpected event could inhibit a true assessment of the actual number of laser incidents (Harris, Lincoln et al. 2003). Collection of this “near-miss” data could add value to the study of surrounding events or system characteristics that may lead to possible injury.

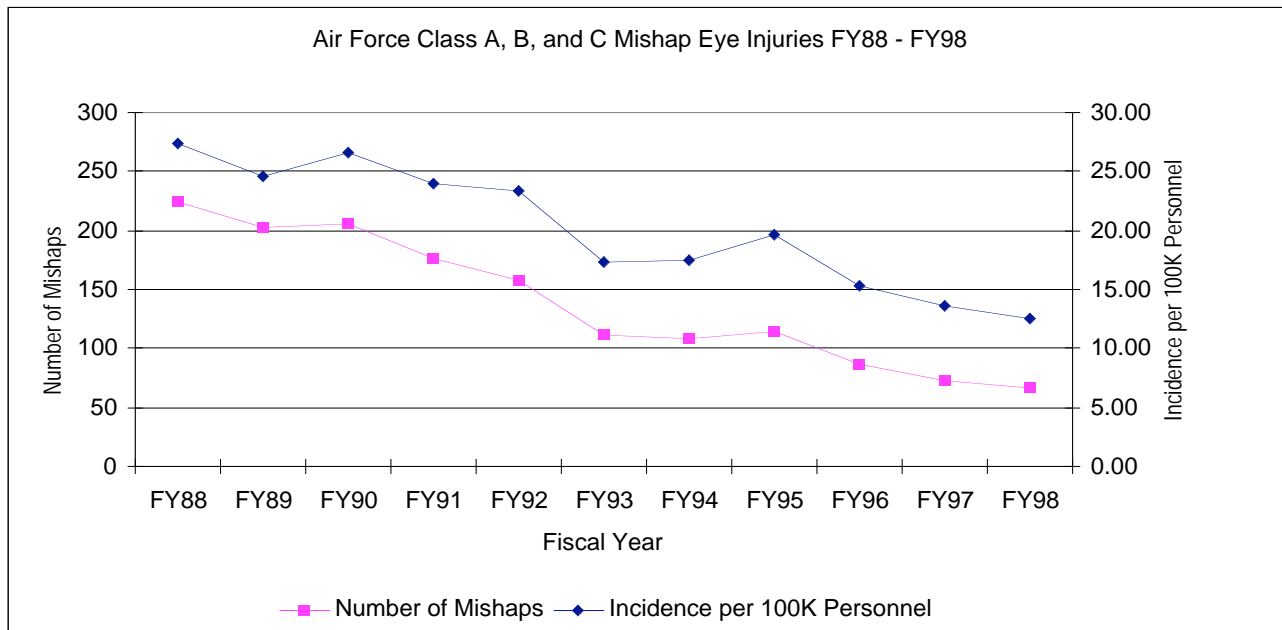
### **2.3 Broad Eye Injury Trends**

The highest numbers of military eye injuries occur during times of conflict. Military wartime eye injury rates increased from 0.57% to 13 % of all battlefield injuries over the 150-year period between the onset of the Civil War through the Operation Desert Shield/Storm conflicts (Wartime Eye Injury Rates 2004). It is expected that eye injuries will continue in an upward trend during the Second Gulf War and War on Terrorism, due in part to laser eye injuries. It is possible that the increase in number of military laser systems contributed to the elevation of ocular injuries during the Gulf War. It is imperative that data collection for laser incidents is as robust as possible because laser incidents are likely occurring now. This injury data will be lost if not properly reported and documented. Proper collection of laser incident information would allow for analysis of the proportion of ocular injuries resulting from laser systems. An example trend comparison could include an analysis of the increase of all wartime eye injuries in relation to the rate of wartime laser eye injuries.

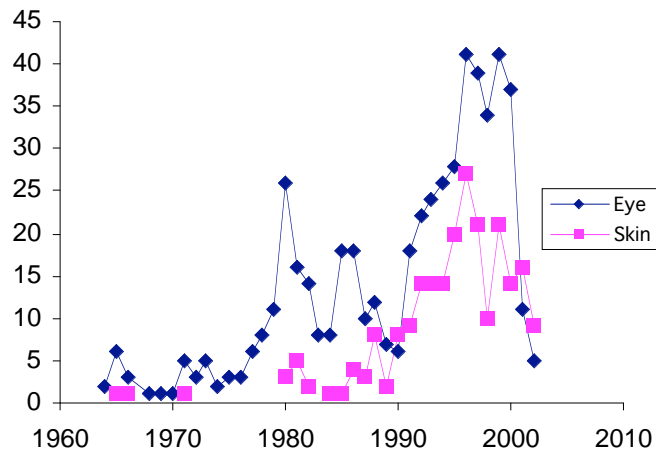


**Fig. 5.** Increasing Wartime Ocular Injuries over 150 Year Period  
Source: Tri-Service Vision Conservation and Readiness Program at the United States Army Center for Health Promotion & Preventive Medicine

A reason it is difficult to distinguish the number of USAF laser eye injuries from the total number of USAF eye injuries is because there is no specific code for laser injuries in the NATO Standard Agreement (STANAG) 2050. STANAG is the standard injury coding system used by the US military and other NATO countries. Air Force eye injuries decreased by greater than a factor of two from 1988 to 2002 before reaching a plateau from 1998 to 2002, as shown in Figure 7 (Copley, Burnham et al. 2003). Conversely, Keeler's study demonstrated that laser injuries increased in Air Force personnel compared to other military branches (Keeler 2002). Johnson's study showed an increasing trend in overall eye and skin injuries, as shown in Figure 8 (Johnson, Keeler et al. 2003). Laser eye injuries cannot be separated from the overall decreasing eye injury data to determine how the number of eye injuries compares to the upward injury trends described in Johnson's and Keeler's studies.



**Fig. 6.** Decreasing Air Force Eye Injury Statistics  
Source: Air Force Safety Center



**Fig. 7.** Johnson's Study of Eye and Skin Injuries from 1965-2002.

These two studies demonstrated a conflict inherent in research involving eye injuries and laser eye injuries. Possible explanations for Johnson's study results include an increase in injuries attributed to better detection of a constant number of laser injuries, or an actual increase in the number of laser injuries secondary to the proliferation of laser

systems. Additional knowledge about methods of laser injury and reasons for laser injury is key in understanding laser eye injury prevention. An effective laser incident information collection system would aid in the comparison of laser eye injury trends with non-laser eye injury trends.

## **2.4 Personnel Protection**

Engineering controls and personal protective equipment (PPE) are less effective when laser systems are used outdoors (Johnson, Keeler et al. 2003). The unpredictability of combat environments further increases the risk for unintentional laser exposure (Marshall 1999). Factors that contribute to unpredictability include unintended reflection of laser light from surrounding surfaces, error by the laser operator, and technical use limitations such as PPE interfering with necessary job tasks. Potential magnification of light intensity on the eye by use of optics can reach more than a million-fold, further increasing the threat of ocular damage (Barkana and Belkin 2000). Unexpected laser exposure makes training and personnel protection extremely difficult in both field and training environments.

## **2.5 Unconventional Warfare**

Enemy laser weapons used in the battlefield or during acts of terrorism are potential threats to military personnel. A ban was placed on intentional blinding laser weapons under the Geneva Convention Protocol on Blinding Laser Weapons (Protocol IV, Oct. 29, 1995)(Hudson 1998). Anti-personnel laser systems have been developed to intentionally cause retinal damage and blindness in large numbers of battlefield combatants despite the ban (Hudson 1998). Laser weapons can be used to blind or dazzle adversaries during critical operations possibly leading to fatal outcomes. Some laser

systems may employ tunable lasers or concurrently emit multiple laser wavelengths to overcome conventional methods of personnel protection (Anderberg and Wolbarsht 1992). Aircrews and special operations forces are two occupations at risk of injury from enemy lasers in the battlefield, as anti-personnel and anti-material lasers become more prevalent.



**Fig. 8. Chinese ZM 87 Laser**  
Source: National Air Intelligence Center

## 2.6 Medical Care and Surveillance

The goal of this study was to identify baseline medical and occupational safety data collection needs in order to create a laser incident reporting form. The purpose of the form was to provide researchers with more comprehensive and complete data to identify incident trends. This data could also be used by medical and safety personnel to better diagnose and treat laser injuries as well as enhance laser safety programs.

The use of a standard laser incident reporting form to collect data for tracking injuries over time will help medical personnel assess effectiveness of laser injury

evaluations. Collecting medical evaluation data will provide a basis to establish preventive medicine guidelines for better personnel protection through recommendations of the most effective exams. Documentation of medical care and follow-up over time is necessary after a laser event to determine typical recovery times and effective injury treatments. As an example, documentation could allow comparison of treatments to determine if vision is recovered more quickly or thoroughly using one treatment over another. Medical treatment research could be focused to address the most common types of injuries.

A laser incident reporting form that helps with tracking laser injury trends would greatly contribute to the development of a surveillance program. Surveillance is considered to be the driving force of injury research and prevention efforts. The surveillance process employs a standard mechanism for identifying occupational groups with high frequency of injury and risk of injury (Lincoln, Smith et al. 2000). Furthermore, Lincoln states that priority areas based on the magnitude of the problem and risk of injury may not be recognized without proper attention to surveillance. The opportunity to prevent laser injuries may be lost without an effective surveillance system (Lincoln, Smith et al. 2000). A robust surveillance system will provide concrete information to identify priority areas of military laser protection. Decisions could be made for focusing resources toward development of enhanced safety mechanisms and PPE with a scientifically designed surveillance program. Additionally, training efforts could be initiated to target specific Air Force personnel based on risk factors identified through a properly designed surveillance system.

## **CHAPTER THREE: METHODS AND MATERIALS**

### **3.1 Data Confidentiality**

A minimum risk research protocol was submitted for the use of human subjects to both the Office of Research and the Institutional Review Board (IRB) of the Uniformed Services University for the Health Sciences (USUHS) to ensure protection of survey participants. IRB requirements and accompanying documents included an informed consent form, survey questionnaire and text of the e-mail used to introduce the study (Appendices A-D).

### **3.2 Delphi Technique**

The Delphi technique was used to determine core data collection requirements for creating a laser incident reporting form. Expert opinions were obtained through a series of surveys to determine data that should be collected on the incident form. The Delphi technique allows survey participants from all over the world to provide input in a study. An acceptable attrition rate of approximately 38% of initial survey participants is considered to be acceptable for the Delphi Technique (Cyphert and Gant 1971).

The Delphi technique as adopted for this study consisted of the following basic steps, utilizing formats from other Delphi technique studies (Cline 2000; Bishop 2002):

#### **Phase 1: Planning**

- Developed a workgroup to define objectives of the study and identified survey questions.
- Assigned a Project Coordinator to guide the workgroup.
- Identified a panel of experts on the subject matter of the study to serve as panel members.
- Developed the questionnaire, consisting of a few open-ended questions.

#### **Phase 2: Round 1**

- Distributed the questionnaire to the panel members with a cover letter explaining the purpose of the survey and what was expected of them.
- Analyzed results of the initial questionnaire utilizing the workgroup.

#### Phase 3: Round 2

- Returned all results to panel members for review, comments and clarification of items on the list.
- Repeated analysis of results by workgroup and distributed the updated survey to the panel members until a consensus was reached.

#### Phase 4: Final Round

- Sent a final survey to panel members to rank their list of results by order of importance on a scale of 1-5.
- Analyzed ranked results and determined most important items to be included in the laser incident reporting form.

#### Phase 5: Create Form

- Created a draft laser incident reporting form comprised of items identified by the Delphi technique.
- Performed cognitive interviews to test comprehension of the form.
- Revised final form based on feedback from cognitive interviews.

### **3.3 Panel Member Recruitment**

Flight Surgeons, Ophthalmologists, Bioenvironmental Engineers and Health Physicists were selected to comprise the four initial expert panels because these occupations are directly involved in responding to laser incidents. The Air Force directs personnel with a suspected eye or skin injury to report to a Flight Surgeon or Eye Care Specialist for medical evaluation. A Bioenvironmental Engineer (BEE) or Health Physicist (HP) is most often the expert involved in a laser incident investigation. The Base Laser Safety Officer is typically a member of one of these two safety groups. Potential panel members with specific laser injury experience or knowledge were recruited to participate in the Delphi survey.

E-mails were sent to USAF specialty leaders for each of the four panels to ask for permission to conduct a laser incident research project with their personnel. The initial contact with specialty leaders served also as a request for the recommendation of five experts in their respective field knowledgeable of laser injuries. The five experts were to



establish a basis for recruiting potential panel members. All four specialty leaders agreed to collaborate on this project. Two of the specialty leaders answered the request for initial contacts. Ophthalmologists and HPs each returned at least five requested names of contacts and their contact information. Flight Surgeon and BEE specialty leaders provided no contacts for the study. Residents in Aerospace Medicine were recommended as a resource for recruiting Flight Surgeon panel members with expertise in laser incidents because of their specialized training. This panel was referred to as “DOC” for the study. Eye care specialists, such as optometrists or other individuals specializing in laser eye injuries, were added to the Ophthalmologist panel collectively referred to as the “EYE” panel. Individuals other than ophthalmologists were recruited due to low numbers of potential Ophthalmologist panel members identified during the recruiting process. Laser safety experts who were not necessarily health physicists were added to the HP panel. Some of the added laser safety experts specialized in laser safety and biological effects (bioeffects) research. It was determined that their laser expertise should be included in the HP panel. Several members were dually qualified as HP and BEE. Dual qualified HP/BEE were used to complete the BEE list if they were not recommended for the HP list because there were few BEE potential panel members identified during the recruiting process. Panel member criteria were established prior to the study with the following requirements:

1. The panel member had to meet the requirements for one of the four expert panels (BEE, HP, DOC, or EYE).
2. The panel member had to have expertise based on academic or practical experience with lasers in either a safety or medical setting.
3. The panel member had to be an officer or officer equivalent including DoD civilians and contractors

4. Each panel member agreed to voluntarily participate in the survey and to supply information about data collection relevant to laser injuries respective to his or her area of expertise.

### **3.4 Delphi Round 1**

Two initial components of the Delphi technique were to determine questions that should be asked of the participants, and what background information to provide to potential panel members. Information from available laser incident databases and literature searches were used to develop the initial survey documents (Wolfe 1985; Green, Cartledge et al. 1988; Rockwell 1989; Prevention and Medical Management of Laser Injuries 1990; Hudson 1998; Laser Radiation Protection Program 1999; Barkana and Belkin 2000; Lincoln, Smith et al. 2000; Seet and Wong 2000; Keeler 2002; Barat 2003; Harris, Lincoln et al. 2003; Johnson, Keeler et al. 2003). The survey instrument consisted of an open-ended questionnaire designed to collect information about the importance of various types of laser incident data. This questionnaire was administered as the first round of the Delphi survey. Information was requested concerning four specific areas: demographics, laser system characteristics, event details and medical data. A fifth question was included to allow participants to identify information they felt was important, but was not addressed in the four main questions. Identical questionnaires were distributed to the potential panel members. A two-week turnaround time was given for panel members to complete and return the survey. The text of the e-mails and attachments sent to potential panel members for Delphi Round 1 are detailed in Appendix B, C, and D. Contact was defined as the successful delivery of an e-mail sent to one of the 81 potential panel members (not returned to the sender). Potential panel members

who did not want to participate in the survey or did not feel qualified to complete the survey had the option to select either of these two options as a reason for declining.

### **3.5 Delphi Round 2**

The first round of responses from panel members was pooled into the five survey categories (demographic, laser system, event, medical, and other) to form a single generic data set with personal identifiers removed. The second Delphi round of compiled surveys was sent to panel members who responded to the initial questionnaire. The purpose of the second survey round was to ask for clarification of items submitted during the first round, or to add new items to the list after reviewing results from the first round. Panel members returned surveys from the second round with notation of any changes, clarifications or additions to the survey document. An indication on the form was available to allow the participant to choose not to review or critique a particular section of the survey if a panel member was not comfortable ranking items outside his area of expertise (e.g., a health physicist not desiring to provide input about medical data due to lack of familiarity with that section). A checkbox was provided on the form to designate that no changes were made after reviewing a section.

### **3.6 Final Delphi Round**

The Delphi technique is considered to be nearly complete when no new ideas are added to the compiled data set from the previous round, which occurred during Round 2. Items from the list not meeting the scope of the project were removed from the final questionnaire. Each item on the list was reviewed to determine if it met the following criteria:

1. Can an answer to this item be reasonably collected in a database? (Reduction of open-ended items.)

2. Will the item contribute to identifying people at risk of laser incidents/injury or situations/events/factors contributing to incidents?
3. Will a database query on an answer to the survey item give useful information for studying laser incident trends?
4. Will an answer to the survey item contribute to effective medical treatment?

The final revised list was returned to panel members to allow them to rank the importance of each remaining item on a Likert scale of 1-5: 5-very important, 4-important, 3-undecided, 2-unimportant, 1-very unimportant.

### **3.7 Laser Incident Form**

Ranked survey items were used to create the draft laser incident reporting form based on importance as determined by panel members. An analysis of data from Round 3 was performed to determine which items were the highest ranked. Results from the final Delphi round were recorded in a spreadsheet for analysis. The following algorithm was used to determine which Delphi survey items were included in the laser incident reporting form:

1. The overall mean was calculated for each survey item on the list (e.g., date of birth), based on ranking by all the final Delphi panel members. The overall mean was calculated by summing the rankings for an item and divided by the number of panel members ranking that item.
2. Panel means were calculated for survey results from each of the four panels (BEE, HP, DOC and EYE). The same method was used as calculating the overall mean except the mean was calculated for each of the four panels.
3. Group means were calculated for Safety (BEE and HP) and Medical (DOC and EYE) panel responses. The same method was used as calculating the overall mean except the mean was calculated for both groups.
4. The grand mean, or mean of the means, was calculated for each section of questions: demographics, laser system characteristics, event details, and medical data. This resulted in one grand mean for each section for a total of four grand means.

5. Standard deviations were calculated for each of the grand means.
6. The first round eliminated any item with an overall mean value less than the grand mean minus one standard deviation.
7. The second round of eliminations included any item that had three panel means less than the grand mean of the respective section. If there were only three panel means, which occurred if an entire panel did not rank an item (e.g., all BEE panel members abstaining from ranking the importance of a particular medical exam), then all three remaining panel means had to be less than the grand mean to eliminate that item.
8. An additional criterion was used to eliminate items from the medical section. Items were eliminated if the Medical group mean was less than or equal to the grand mean.

Upon completion of a draft laser incident reporting form, cognitive interviews were conducted for feedback regarding functionality of the form and to clarify the interpretation of data fields. Individuals were recruited for cognitive interviews using the same method as recruiting panel members. Individuals who did not participate in the Delphi survey were recruited for cognitive interviews to obtain an objective viewpoint of the incident form. One individual from each expert group (i.e. HP, BEE, DOC and EYE) was contacted by phone to review the draft form for a total of four cognitive interviews. Each expert was instructed to complete the draft incident form as if reporting a real incident. Cognitive interviews were used to identify and correct data fields for the final laser incident reporting form.

## CHAPTER FOUR: RESULTS

### 4.1 Delphi Round 1

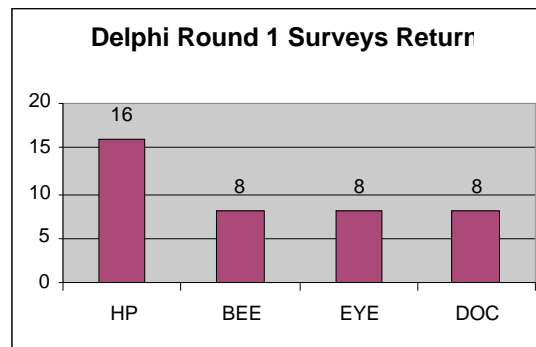
A total of 81 e-mails were sent to potential laser survey panel members (Table 1). Of the 81 surveys, 88.9% successfully contacted a valid e-mail account. Of the 72 successful contacts, over half participated in the survey (55.5%) as shown in the final column of Table 1. The “Participation Response” column represented the number of panel members that participated of the successful contacts. Only 18.1% of successful contacts responded with a choice to decline participation in the survey. The most common reason for declining to participate was lack of laser experience. Time constraints and travel were also cited as reasons for not participating. “No Response” was recorded for surveys that reached a valid e-mail address, but the potential panel member gave no reply to the request for survey participation.

**Table 1.** Delphi Round 1 Survey Summary

Delphi Panel	Sent	Contact	No Contact	Participated	Declined	No Response	Percent Participation
HP	26	25	1	16	3	6	<b>64.0%</b>
BEE	17	15	2	8	4	3	<b>53.3%</b>
DOC	16	15	1	8	2	5	<b>53.0%</b>
EYE	22	17	5	8	4	5	<b>44.0%</b>
Total	81	72	9	<b>40</b>	13	29	<b>55.5%</b>

The HP panel had the highest number of contacts at 25, for 64.0 % participation when grouped by panel. Individuals choosing to decline made up 12.0% of successful HP contacts, with no response from 24.0% of contacted potential panel members. BEE had the second highest participation percentage of the four groups with 53.3%. Of the 15 BEE potential panel members successfully contacted, 26.7% declined and 20.0% did not respond. DOC had a participation of 53.0% of the 15 successful contacts. Of the DOC contacts, 13.3% declined and 33.3% did not respond to the initial Delphi survey. Less

than half of EYE potential panel members participated although they had the second highest number of successful contacts (44%). Of the 17 EYE potential panel members successfully contacted, 23.5% declined and 29.4% did not respond. The Safety group had 60.0% participation and Medical had 50.0% participation when combined by group. The 40 individuals who participated in the first survey were referred to as panel members, instead of potential panel members, for the remainder of the study. HP made up 40.0% of the panel members that responded to the first Delphi survey. The three remaining panels each made up 20.0% of the 40 panel members.



**Fig. 9.** Delphi Round 1 Participation Results

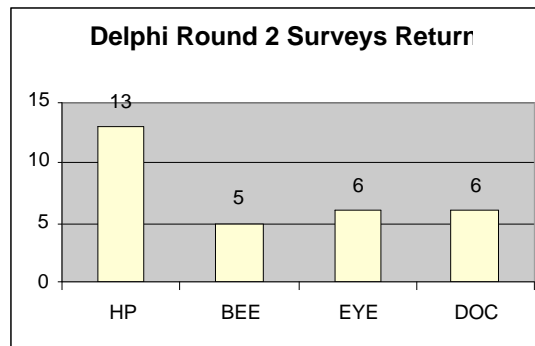
## 4.2 Delphi Round 2

In the second round, surveys were sent to the 40 panel members who participated in Round 1. The second survey was a compilation of all input received from Round 1 panel members. Participation results of the second Delphi round are listed in Table 2.

**Table 2.** Delphi Round 2 Survey Summary

Delphi panel	Surveys Sent	Participated	Dropped Out	Percent Participation
HP	16	13	3	81.3%
BEE	8	5	3	62.5%
DOC	8	6	2	75.0%
EYE	8	6	2	75.0%
Total	40	30	10	<b>75.0%</b>

The HP had the highest participation rate, followed by EYE, DOC and BEE, respectively. Safety and Medical groups each had a 75.0% when combined by group. All survey panels had a cumulative participation response of 75.0% overall. A total of 30 panel members responded to Round 2 of the Delphi survey. The final round was limited to those 30 panel members. Panel members that did not participate in the second Delphi survey gave no explanations for withdrawal from the survey.



**Fig. 10.** Delphi Round 2 Participation Results

Items from the fifth survey question, where panel members added laser incident items not addressed one of the other four sections, were either incorporated into one of the other four sections or considered to be outside the scope of the laser incident reporting form. Most of the items submitted for the fifth survey question were related to classification and data confidentiality matters. The fifth survey question was eliminated after the second Delphi round was completed. Each survey item submitted by panel members from Round 2 was reviewed to remove duplicates and to eliminate items



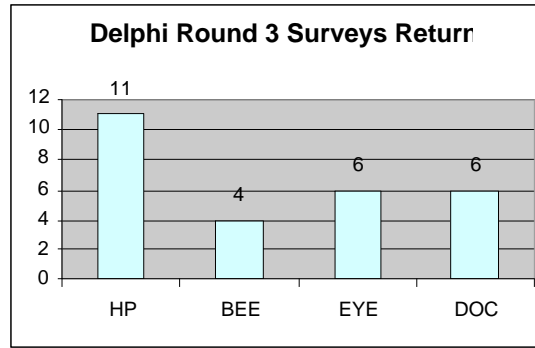
outside the scope of the laser incident reporting form. Survey items that would result in lengthy open-ended answers were removed to optimize the size and length of the form. Another reason for removing open-ended items was to simplify data collection for comparison of incident trends as will be explained in the Discussion chapter.

### 4.3 Delphi Round 3

The final round of surveys was sent to 30 panel members with 27 returning ranked surveys. HP accounted for 40.7% of the ranked surveys. HP had a high attrition rate, losing two panel members (15.4%) in the final Delphi survey. BEE made up 14.8% of the final Delphi surveys with the highest attrition rate of 20.0%. DOC and EYE specialists made up 22.2% of ranked surveys each. The safety group had 83.3% participation while the medical group achieved 100.0% participation in the final round. Total percent participation for all panels in Round 3 was 90.0%. Panel members not participating in the third Delphi survey gave no explanation for withdrawal from the survey.

**Table 3.** Delphi Round 3 Survey Summary

Delphi panel	Surveys Sent	Participated	Dropped Out	Percent Participation
HP/Laser Specialists	13	11	2	<b>84.6%</b>
BEE	5	4	1	<b>80.0%</b>
Flight Surgeons	6	6	0	<b>100.0%</b>
Eye Care Specialists	6	6	0	<b>100.0%</b>
Total	30	27	3	<b>90.0%</b>



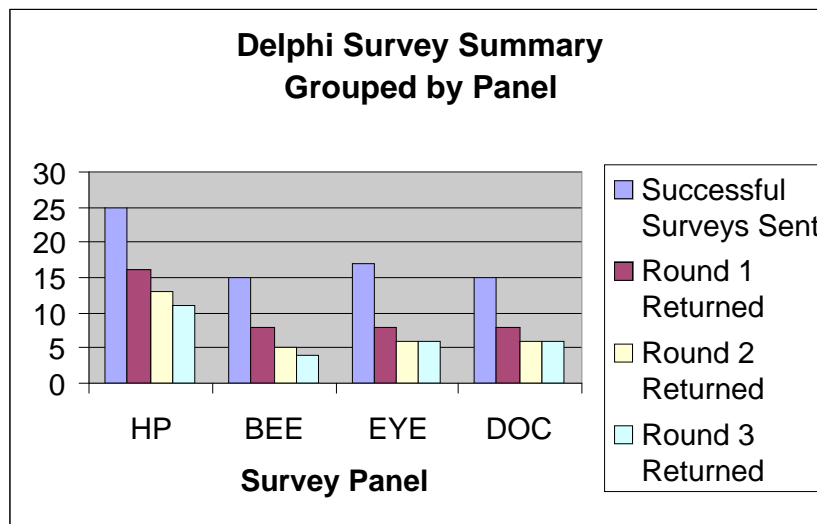
**Fig. 11.** Delphi Round 3 Participation Results

#### 4.4 Final Delphi Survey Results

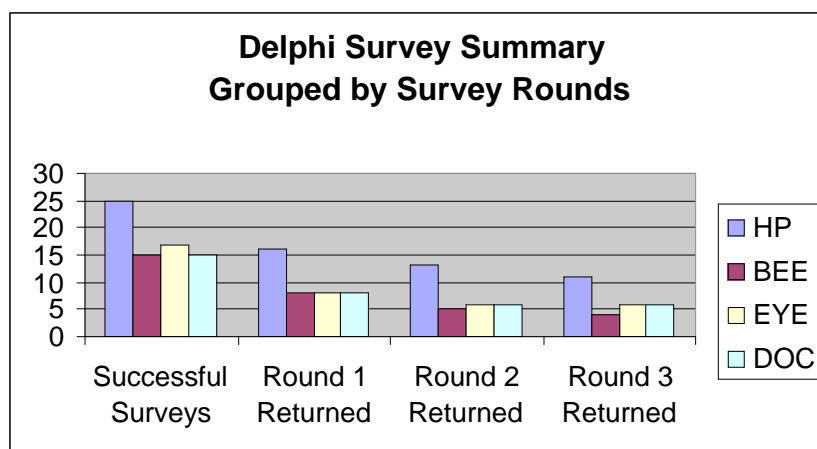
For three rounds of the Delphi study, DOC and EYE had the highest participation response of 75.0%. HP had the next highest participation response of 68.8%. BEE responded with only 50.0% participation. Safety had 67.5% participation and medical had 75.0% participation when combined by group. Overall, the four combined panels had 67.5% participation. Survey participants dropped from 40 members agreeing to participate to 27 members at the conclusion of the Delphi surveys. The attrition rate for the surveys was 32.5%. The attrition rate for this study was within the 38% criterion established prior to the study. Table 4 represents panel member participation for the three Delphi rounds and overall participation. Figures 12 and 13 illustrate surveys grouped by Delphi panel and surveys grouped by Delphi round, respectively. Each consecutive round had a higher percentage of the panel members participating with both Flight Surgeons and Eye Care Specialists at 100.0% participation for Delphi Round 3.

**Table 4.** Overall Participation Percent

Delphi panel	Round 1	Round 2	Round 3	Overall participation
HP/Laser Specialists	64.0%	81.3%	84.6%	<b>68.8%</b>
BEE	53.3%	62.5%	80.0%	<b>50.0%</b>
Flight Surgeons	44.0%	75.0%	100.0%	<b>75.0%</b>
Eye Care Specialists	53.0%	75.0%	100.0%	<b>75.0%</b>
Total	55.5%	75.0%	90.0%	<b>67.5%</b>



**Fig. 12.** Delphi Survey Summary Grouped by Panel



**Fig. 13.** Delphi Survey Summary Grouped by Round

#### 4.5 Laser Incident Reporting Form

A laser incident reporting form was developed after analyzing results of the final Delphi survey. The laser incident reporting form had four sections, corresponding to the four sections of the Delphi surveys: demographic, laser system characteristics, event data and medical information. Data was analyzed using the elimination criteria as described in the Methods and Materials chapter to determine the highest ranked responses. Items not removed from the list by the elimination criteria were included on the laser incident

reporting form. Items retained for the incident form included the following: Personal Information, 12; Laser System Information, 22; Details of the Event, 24; and Medical Data, 42.

**Table 5.** Delphi Form Items

Delphi Results for Creating the Laser Incident Reporting Form				
Data Section	Total Number of Items	Items Retained for the Form	Eliminated Items	Percentage of Items Retained
Demographic	13	12	1	92.3%
Laser System	34	22	12	64.7%
Event Details	43	24	19	55.8%
Medical Data	75	42	33	56.0%

One individual who did not participate in the survey was selected to represent each of the four panel-types to complete a cognitive interview: Health Physicists/Laser Specialists, Bioenvironmental Engineers, Flight Surgeons and Eye Specialists. Cognitive interviews were used to ensure the volunteers understood the data being requested on the form (e.g., an interviewee not knowing how to enter data into a particular field of the form would indicate a potential problem with the wording of the form). Few problems were discovered during the cognitive interviews. Problems that were found consisted mostly of comprehension issues with wording of the draft form. Time to complete the survey ranged from approximately 15-25 minutes. Any difficulties with items on the laser incident reporting form were documented during the cognitive interview. Minor changes and clarifications were incorporated into the final laser incident reporting form (Appendix E).

## **CHAPTER FIVE: DISCUSSION**

### **5.1 Overview**

The Delphi technique was a useful tool for a joint decision-making approach to creating a laser incident reporting form. There were several reasons for selecting the Delphi technique for this laser incident form study. One reason was the low cost of using the Delphi technique. The only cost incurred during this study came from contacting potential panel members and conducting cognitive interviews over the phone and time involved to conduct the survey. Conducting surveys via e-mail not only kept costs low compared to mailing surveys, but also served as a convenient medium for contacting panel members and receiving their completed surveys. Panel members had the flexibility to complete surveys at their leisure. Furthermore, there was little time and no travel required for the panel members to complete surveys as would be necessary to conduct live interviews. E-mail was also a convenient method that would allow panel members to return the survey electronically rather than using postal mail. The electronic survey responses were readily accessible for creating compiled lists and analyzing ranked responses. The Delphi technique was considered to be the optimal method for the limited amount of time available for data collection. Approximately three months of data collection were needed to complete this study.

Another advantage of using the Delphi technique was to overcome geographic disparity of panel members. Panel members could participate in the survey from any location as long as they had e-mail access. Data confidentiality was not complicated using the Delphi technique because panel members were not given the names of other survey participants. Anonymity of the Delphi technique was valuable for soliciting

opinions from military members. Rank and status may have an influence with survey responses if participants know the other panel members. Another benefit of anonymity was that panel members had no direct contact with each other as in a group interview that may allow others to influence their responses.

Disadvantages of the Delphi technique included the inability to obtain complete clarification of responses. E-mail surveys did not have the benefit of instant feedback as in a live discussion. Low participation is always a potential limitation when using a survey as a data collection instrument.

## 5.2 Delphi Panel Member Profile

There is no set number of panel members required to perform a Delphi survey. A typical Delphi survey has a number of panel members ranging from 15 to 35 participants (Bishop 2002). Few new ideas are generated once the size exceeds 30 panel members within a homogeneous panel (Debelcq, Van de Ven et al. 1975; Schopper, Ammon et al. 2000). The Delphi technique does not gain reliability with greater than 30 participants (Adams 2001). The number of at least 15 potential members per panel was chosen to allow for refusals, dropouts, and failed contact attempts. Medical and safety groups consisted of two panels each for a total of 30 members per group, as shown in Table 6. Medical and safety groups were considered to be two homogenous groups for this study.

**Table 6.** Potential Panel Members

Delphi Expert Panels	Desired number of initial panelists	Panel Grouping
Health Physicists/Laser Specialists (HP)	15	30 Safety Panelists
Bioenvironmental Engineers (BEE)	15	
Flight Physicians (DOC)	15	30 Medical Panelists
Eye Care Specialists (EYE)	15	
<b>Total</b>	<b>60</b>	<b>60</b>

There were some challenges in recruiting contacts for participation in the Delphi survey. Potential panel members with laser experience were identified through specialty leaders or by contacting individuals within the desired career fields. These potential panel members were contacted by phone or e-mail and asked to provide additional contacts in their field with laser experience. Some potential panel members provided contact information for additional potential panel members outside their own expert panel. These referrals helped fill panels where members were still needed. On the other hand, the large number of potential HP panel members specializing in lasers was attributed to an initial high number of contacts and participation. Contact information was provided through assistance from the health physics specialty leader and other health physicists or laser specialists. The process of recruiting potential panel members through referrals was successful in completing the four panels.

A few panel members were recruited outside the Air Force community to add members to panels that were difficult to fill. These members were included because they were recommended as being knowledgeable in the area of military laser incidents and often worked side-by-side with Air Force Personnel towards a common goal of personnel protection. Some civilians and contractors recruited as panel members were prior active duty military members or reservists giving them added experience in working in a military environment. Contacts submitted outside the panel member criteria were excluded from the study. Knowledge of or experience in a military environment was a key condition for participating in this study.

There was a potential bias introduced into the study due to the method of panel member recruitment. There is a tendency for individuals to recommend colleagues with

like-minded viewpoints when asked for referrals of additional potential panel members. Most of the individuals of a given panel likely received similar laser injury and protection training that may also introduce bias. This bias may be more pronounced if a person has limited experience working with laser systems or laser injuries. It is impossible to determine how well alternative viewpoints were represented for developing the laser incident reporting form. This represents a study limitation of using potential panel members to recruit additional panel members.

### **5.3 Delphi Round 1**

A low participation was anticipated for the initial Delphi survey due to military duties, such as patient care workloads, travel, training requirements and deployments. At least one potential panel member could not be contacted because of a deployment. The high overall response of 64.0% from HP was likely due to specialized laser training and experience within this panel. The HP occupation specializes in ionizing and non-ionizing radiation to include lasers. Many individuals who met the requirements of the HP panel had direct research experience in the field of laser safety and bioeffects. Their participation may have been higher because they already have a vested interest in personnel protection.

It was difficult to recruit DOC panel members who had laser experience, which contributed to having a lower than desired number of participants for the first Delphi survey. Laser injuries are still unique and often unreported, so Flight Surgeons may never treat a laser eye injury or have specialized training in laser injuries beyond their RAM training. Complaints about loss of vision would likely be referred to an eye care specialist as a symptom of exposure since the eyes are the organs at greatest risk of



injury. BEE and EYE panel members were difficult to recruit and also had a lower than desired participation for Round 1.

#### **5.4 Delphi Round 2**

Round 2 had a higher response rate (75.0%) than the initial round. This was most likely due to the fact that all e-mail addresses were confirmed and initial panel members were already identified. People who participated in the first round had already demonstrated an interest in the survey. The low participation rate of 62.5% for BEE panel members during this round may possibly be attributed to demanding workloads, a lack of interest or lack of expertise in working with lasers. A low BEE participation was not considered to be a problem because there was a high HP participation to help represent the safety group.

Some of the attrition from this round was most likely due to the length, detail and time to complete this survey round. The list of responses from the first survey became very long after compiling all panel member responses into a single document. The resulting list was found to be burdensome by a few survey participants. One reason for the length of the survey was due to duplicate or similar ideas on the compiled list. Another reason was because some participant responses were outside the scope of creating the laser incident reporting form. The opportunity for panel members to review responses from Round 1 was an essential step for Round 2. A better approach possibly would have been to shorten the length of the list for Round 2 by summarizing and combining responses, rather than including items nearly all items from Round 1. However, new ideas and clarification of survey items were exhausted during this round allowing panel members to reach a consensus on the listed items.

### **5.5 Delphi Round 3**

Several survey items from the prior round were modified or eliminated to clarify items and reduce duplicates before sending Round 3 surveys. Some items that were removed included broad, open-ended questions about the details of the laser event. This type of free-text is highly subjective and is open to interpretation of the reviewer who reads the text. Searching free-text fields may make it difficult for a reviewer to extract common variables for laser incident trend analyses. These searches can also be very time consuming. Free-text fields also tend to be inconsistent because each form may have varying levels of detail for a given field. The same type of information may not be entered into the same location on the form using free-text fields. Other items removed from the list included personal information, such as names of supervisors, phone numbers, and addresses. Personalized fields tend to become quickly outdated as people move to other buildings, offices or jobs. They may also become an issue under the Health Insurance Portability and Accountability Act of 1996 (HIPAA) privacy standards. HIPAA is a requirement overseen by the Department of Health and Human Services to provide security and privacy of health-related personal data.

The BEE panel participation tapered to only four panel members ranking items on the final Delphi survey. This did not pose a problem to the study because the weight of the four panels was evenly distributed based on the exclusion criteria. Elimination of an item relied on the grand mean minus one standard deviation or three panel responses. No panel was given enough influence to eliminate a survey item by itself. The medical section was an exception, where more influence was given to the Medical group to eliminate survey items with the additional criterion. However, the extra criterion for the

medical section did not include the BEE and HP groups. Furthermore, there was less of an influence due to the low BEE response to the medical section.

A total of 15 participants for the safety group and 12 participants for the medical group completed the third survey. The safety group was well represented despite the low BEE participation, having more participants at the conclusion of the final round than the medical group. Finally, a higher number of panel members ranking the third survey may have made the analysis of ranked responses easier by establishing a greater difference between the highest and lowest ranked items. However, more participants ranking the final list probably would not have influenced the outcome because the Safety and Medical groups were both well represented. The number of participants from the four panels completing Round 3 was satisfactory because the Delphi technique utilizes experts instead of random sampling.

All four panels had increasingly higher participation percentages with each consecutive round, but had fewer panel members responding. An exception was the DOC and EYE panels having the same number of participants from Round 2 to Round 3 for 100.0% participation. A decrease in the number of panel members in a Delphi study is expected because panel members not responding to a given round are no longer retained in subsequent survey rounds. Attrition may introduce bias into the study because panel members remaining through the final round of the Delphi technique are the only ones permitted to rank the final list. It is not possible to determine if panel members remaining in the study were different than those that discontinued participation during one of the Delphi surveys.

An item of note was that skin injuries were of low interest to the panel members, although the eye is not the only organ at risk of laser injury. No information about skin other than location of the injury was retained for the laser incident reporting form. It may be worthwhile to pursue the opinions of dermatologists or other skin injury experts as a future study to determine whether additional information about skin injury should be collected. Panel members may not have considered skin injuries to be as detrimental to human health or the military mission compared to the loss of vision.

### **5.6 Laser Incident Reporting Form**

The goal of the study was to produce a form for collecting laser incident data using the highest ranked survey items from the Delphi technique. The analysis of rankings from the third Delphi survey helped ensure collection of the most critical laser incident information via the incident form. It was important to ensure the length of the form was manageable by its users. A long form may result in the loss of valuable laser data if the form is not used or is incompletely filled out due to the excessive time required to complete it.

The same criteria were applied to all of the sections of the form. The grand means and standard deviations were used for selecting items that were included in the laser incident reporting form. An extra criterion was added to the medical section of the form because there were more than 50 remaining survey items after the initial criteria. The high number of remaining items was partly because the BEE panel abstained from ranking some of the medical items only leaving three panels to rank some of the medical section items. If an entire panel did not rank an item, all three remaining panel rankings were required to fall below the grand mean for the second elimination criterion.

Requiring all three panels for elimination of an item attributed to leaving the high number of survey items in the medical section after the first two criteria. The medical group means were used as the final elimination criterion because of their medical knowledge and expertise. Low BEE and HP panel responses in the medical section were anticipated considering the specialized knowledge of physiology of the human eye and purpose of each eye exam required to rank some of the medical section items. Panel members were only required rank areas where they had expertise. The extra criterion of eliminating medical group means that were less than or equal to the grand mean reduced the number of medical items from 51 to 42.

The form was divided into four sections based on categories used in the survey process. Similar laser incident information was grouped together to make the form more practical for health and safety professionals to complete (e.g. medical information grouped in one section to clearly identify information to be completed by ophthalmologists or flight physicians). Similar data fields were grouped together to maintain a logical flow of data (e.g., keeping information about laser controls together).

All four experts participating in cognitive interviews offered to review the entire draft laser incident reporting form. Their willingness to review the entire form demonstrated the functionality of the laser incident form design because the four interview participants could enter incident data outside their areas of expertise without difficulty. Overall, the consensus of the cognitive interviews was that having an instrument such as the draft laser incident reporting form would be useful for their needs. The check boxes on the form were considered to be especially useful for incident data collection.

## 5.7 Power Study

It is important to know number of laser events that are necessary to achieve a minimum detectable level because laser injuries are so rare. A power study was performed to determine the required number of incidents above background to establish a trend. The equation for the Lower Limit of Detection (LLD) was used to estimate the minimum number of laser incidents in one year to verify an increase in laser injuries (Appendix F).

$$\text{The LLD equation} = 4.1653\sigma_{NB} + 2.706$$

Number of events detected –  $N_D$   
Number of background events –  $N_B$   
Assume:  $N_D / N_B \ll 1$ ,  $\sigma_{NB} = \sqrt{N_B}$   
Find  $N_D$  as a function of  $\sigma_{NB}$   
 $\alpha = 0.05$ ,  $\beta = 0.05$

A current analysis of the unified database resulted in 30 military laser events reported over a period of 36 years.

$$N_B = 30 \text{ events} / 36 \text{ years} = 0.833 \text{ events/year}$$

$$\sigma_{Nb} = \sqrt{N_B} = \sqrt{0.833} = 0.913 \text{ events per year}$$

$$\text{LLD} = 4.1653 (0.913) + 2.706 = 6.51$$

Therefore, a minimum of 7 laser incidents is necessary to identify an increase in incident rate with 95% confidence.

Researchers should be able to get a better estimate of the background number of laser incidents with a more consistent reporting process that allows all incidents to be captured in one location. Consistent reporting will allow for more detailed analyses of risk factors and personnel at risk of laser exposure.

## **5.8 Personal Identifiers**

The privacy of an individual's medical records must be resolved before the medical section of the laser incident reporting form can be used. Storage of medical records is even more critical if the form is developed into a database used for capturing all incident reports. A unique identifier, as recommended by Delphi panel members, should be used for collecting laser event data to protect patient privacy. By law, medical data storage must meet the HIPAA privacy standards. Personally identifying information must be removed for aggregate reporting and trend analysis. Furthermore, personal identifiers add no benefit and are not necessary for analyzing laser incident trends. The creation of unique identifiers and storage of medical records were outside the scope of this study.

## **CHAPTER SIX: CONCLUSIONS**

### **6.1 Overview**

The laser incident reporting form designed through this study offers a standardized collection method for reporting laser incidents. In general, check boxes are used when possible to define discrete fields of data to be collected on the incident form. These discrete fields allow for easier extraction of data for analysis. There are also few free-text fields to minimize subjective analyses of free-text, reduce time to complete the analyses and streamline data collection as mentioned in the Discussion chapter. The best method for analyzing trends would be to enter data from the laser incident reporting form directly into a database so that analyses can be performed. Collecting this data allows researchers to study common trends in laser injuries. These analyses may help identify equipment design problems, high-risk situations or enhance medical evaluations and treatments. The following summary by each section of the form gives some brief examples of discrete data fields and analyses that could be performed.

### **6.2 Demographic data**

The demographic section of the form collects data for the analysis of trends for identifying types of personnel at risk based on job code, age, sex, etc. Methods of reducing laser injuries can be researched after identifying personnel at risk. This may include focusing resources on PPE, training, behavioral modification, or other areas that can help protect USAF personnel. Knowing where to allocate resources is essential to keeping our research on the cutting edge and maintaining a safe and healthy workforce and conserving resources.



Some examples trends in the type of data of the demographic section that could be beneficial for study include:

1. Date of Birth: allows an analysis of trends in the age of injured individuals to see if a particular age group is getting injured more frequently that may direct resources towards training or PPE.
2. Sex: comparison to see if one sex is getting injured more frequently possibly leading to better ergonomic design of the laser system.
3. Rank: may determine if more injuries are occurring with personnel that are more junior or senior, enlisted or officers that may identify a need for additional training.
4. Branch of service: may identify risks or injuries characteristic of only one service that may identify an area of research for better PPE or controls.
5. Status of individual, such as active duty, reserve or civilian: may be useful for identification of higher-risk personnel that require additional training.
6. Job title and job code: identification of individuals at highest risk of exposure based on occupation that may contribute to better PPE or training to lower the risk of injury.

### **6.3 Laser System Information**

Laser system information is useful for analyzing physical system characteristics that contribute to laser injuries such as power, wavelength and PPE. Analyses of trends of system types or system characteristics causing the most injuries allows resources to be focused on designing better PPE, specific training programs, system design features or potential laser system controls. Identifying and modifying a system characteristic may help reduce the number of laser injuries. A trend analysis from the laser system characteristics section may also help identify successful measures of protecting personnel, such as a certain type of control that has a high success rate for protection rather than PPE. System information trends may also aid in the development of future system designs to make them safer based on system designs with a good safety record.

Checkboxes were used in this section as often as possible to simplify comparison of the data. Some data that could be analyzed to identify laser system hazards include the following:

1. Manufacturer name and system name/designator: may determine if a significant number of events were caused by a particular laser system or manufacturer to identify manufacturer or equipment design problems.
2. Wavelength(s): may be used to determine if a specific wavelength or range of wavelengths are responsible for causing a significant number of injuries so that research can be focused on protective measures or alternative wavelengths that are less hazardous.
3. Pulsed or continuous wave and power/energy characteristics: allows for trend identification of physical characteristics of the laser energy that may aid in research of PPE
4. Controls and warning systems: may determine what protective measures are successful or unsuccessful to identify the best controls to install for future laser systems.
5. Personal protective equipment and availability/use of PPE: may identify trends in protective equipment failures or behavior patterns that contribute to or help prevent laser injuries for better training of personnel.
6. Level of training: may be useful to determine what training is most effective or ineffective, or that a higher level of laser training is needed for a particular occupation.

#### **6.4 Details of the Event**

Data from the event details section may allow for a quick comparison of specific laser incident trends as they occur in the field, exercises or during a routine job. This section is simplified for data collection through the use of discrete data fields and checkboxes whenever applicable. These trends may allow for a better determination of high-risk areas of use. Training and early detection systems are potential areas that may be recognized for focusing resources in the area of injury prevention based on the event

scenario. Awareness of high-risk areas and situations could help our military members take precautionary measures to reduce the potential for injury.

1. Items between the laser source and individual's eyes: may be useful for identification of problems with false security of protective equipment or of training on the use of magnifying optics.
2. Enemy forces or friendly fire: may be used to analyze risk factors specific to the intent of laser use for researching protective measures, potential countermeasures and training.
3. Self-inflicted injuries: may be useful for analyzing behavioral or equipment design problems that result in injury.
4. Location of the person, such as battlefield/research/exercise, land/sea/air, ship/tank/bunker: may be used in training personnel on high-risk areas of being in the laser beam path or areas that are likely to be targeted by hostile laser systems.
5. Location of the source: may be useful for identifying whether urban/rural settings or particular laser platforms result in a higher number of injuries that could be applied to better training.
6. Indoors or outdoors: may be used for trend analysis of risk factors or problem areas that may be more hazardous depending on where the event occurs to determine the best methods of personnel protection in these situations.

## **6.5 Medical Evaluation Data**

Background/pre-exposure data, medical incident history, exams performed by medical personnel fields, and results of the exams are some basic fields of the medical section. Trends based on these data may help medical personnel make better diagnoses, determine which examinations are most useful, and become skilled at identifying which treatments are effective in recovering the loss of vision. Medical personnel could use the laser incident reporting form as a resource. The form supplies the fields for relevant data they should collect and symptoms they should observe after a suspected laser exposure. Using this form could reduce the time in diagnosing and treating patients. Time could be

very critical if there were a large number of battlefield casualties due to exposure to an enemy laser system. Some trend information that is beneficial for study from the medical section includes:

1. Visual acuity before/after event: useful for allowing a comparison to see if an individual's exposure resulted in injury or the extent of damage to the eye.
2. Treatment/medication: may be compared before and after the event to see how much a person's condition improved or identify medications that make an individual more susceptible to laser injury.
3. Signs/symptoms: may allow medical personnel to be trained in the most common symptoms of laser exposure and allow a quick determination of whether symptoms can be due to a laser exposure or not.
4. Individual exams: may permit trend analysis of what exams are performed and results of the exam to identify priority exams to be performed in the field to provide necessary material.
5. Follow-up exams: may be used to track trends in recovery from a laser injury to evaluate what types of treatments are most successful.

## **6.6 Recommendations of Potential Databases**

No other Air Force forms consisting of discrete fields are used to collect laser incident data for the purpose of analyzing incident trends. Laser incident reporting forms should be incorporated into a database to provide the most effective means of analyzing trends. There is no simple solution for storing information from the laser incident reporting forms in a database format. The LAIR is one possible solution, but there are some potential drawbacks. Data collected in the LAIR match approximately 60% of the data collected on the laser incident reporting form. Data fields in the laser incident reporting form are much more specific regarding event data than the LAIR. It is possible the LAIR captures information in free-text fields, such as the subject's narrative, that may result in a higher match with the laser incident reporting form. Unfortunately, extracting

data from text fields requires extra time and is subject to interpretation rather than using discrete fields.

The LAIR database is also similar to the four sections of the laser incident reporting form: demographic information, laser system information, event details and medical data. The LAIR is already used to collect medical information, which is an advantage over other databases. One important reason to consider incorporating the form into LAIR is because current USAF instructions already direct laser injury reports to be submitted to LAIR for inclusion in the database. It would be easy to add the laser incident reporting form to the reporting process to ensure more complete, standardized data. However, some modifications would have to be made to the LAIR to incorporate the discrete fields from the laser incident reporting form into the database. A limitation identified with incorporating the laser incident reporting form into LAIR was an issue with classified data. Some of the data collected on the laser incident reporting form may potentially be classified. At this time the LAIR is not capable of maintaining a classified database of laser incidents. A classified database would be necessary in order to collect all laser events in a single location.

The National Air Intelligence Center (NAIC) or Air Force Safety Center may be other alternatives to consider for storing the laser incident reporting form data. Both organizations are able to handle classified information. The NAIC already collects classified laser incident reports. They have approximately 50 laser incidents currently in their database. A secret clearance is required to access these classified records. Forms used by this agency are unclassified until completed with the details of a laser event (Appendix G). Information identified on the laser incident reporting form that is not

collected by the NAIC could be incorporated into their reporting system for a more complete, standardized laser incident report.

The NAIC was contacted about the feasibility of incorporating the laser incident reporting form into their laser collection system. A limitation was discovered with using the current design of the laser incident reporting form. It was determined that the medical data section of the laser incident reporting form would have to be maintained separately to protect the privacy of an individual's medical records and allow medical providers to access the data. A possible solution to this problem is using a unique identifier that allows personal identifiers to be removed. This could allow medical information to be linked to the NAIC data system without the identifiers for laser incident trend analyses. The medical section of the laser incident reporting form would have to be integrated into a separate medical database if the medical section was removed from the current laser incident reporting form either temporarily or permanently. Using the classified NAIC database to collect the laser incident reporting form data seems to be the most practical option explored to date, if a link to relevant medical information could be established. Future study is required to further explore potential options for storing laser incident reporting forms in a central location.

Future efforts should be made for incorporating the laser incident reporting form into a USAF-wide and/or DoD-wide surveillance system. The AFOSHSTD 48-139 is being updated to include the laser incident reporting form. In turn, these forms should be submitted for entry into the most suitable database. A complete USAF laser incident reporting system would be the most advanced method for personnel protection through characterization and medical evaluation of laser incident trends.

## **ACKNOWLEDGEMENTS**

### **THESIS COMMITTEE MEMBERS**

Committee Chair: COL Robert Lipnick, ScD  
Research Advisor: Dr. Thomas E. Johnson, PhD  
Col Thomas Neal, MD  
Maj Scott Nemmers, PhD  
LCDR Doug Fletcher, PhD

### **CONTRIBUTORS**

Col William Butler, 1Lt Kristy Hayes, Dr Deborah Girasek, and Ms Cara Olsen.

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## **APPENDIX A**

### **USUHS IRB Requirements**

IRB requirements include:

1. The proposal had to demonstrate that no personal identifiers were collected that could connect responses of participants to them by name, phone number or other personally identifying information. The purpose was to ensure that no repercussions could be made to an individual as a result of participation in this study.
2. Informed consent statements for survey and interview participation were required for all individuals prior to participating in the study. The purpose was to state the rights and responsibilities as a participant in the study. Additionally, this statement informed participants that they had the right to refuse participation without any recourse at any time during the study.
3. Data collected with personally identifying information had to be stored securely.
4. Data with personal identifiers had to be destroyed at the conclusion of the study.
5. The only personal identifiers collected for study participants were names, phone numbers and e-mail addresses of potential panel members that were not shared with anyone outside the workgroup.
6. IRB approval was given on 18 February 2004 for this project under minimum risk research protocol T087UK authorizing a maximum of 100 subjects to participate in this study.

## **APPENDIX B**

### **Introductory Letter**

From: Krystyn Clark [mailto:kclark@usuhs.mil]  
Sent: Saturday, February 21  
To: RESPONDENT  
Cc:  
Subject: Laser Incident Survey Project

To Whom It May Concern [OR NAME OF INDIVIDUAL]:

You are being asked to participate in a laser incident study conducted by the Uniformed Services University, Department of Preventive Medicine and Biometrics. A survey is attached for the purpose of getting your opinion about data collection regarding health and safety information that would be ideal for studying laser injury trends, risk factors, outcomes, and treatments. There are two important documents attached: 1. An Informed Consent information sheet and 2. Survey. First, please read the informed consent information before responding to any questions in the survey document. Both documents contain more details about this survey process, such as the purpose and potential outcome. Information collected through this survey process will be used to create a standard form to be entered in a comprehensive database of the essential elements needed for laser incident studies. Your response to the survey is completely voluntary. We invite you to participate and believe that your input would be a valuable contribution to this study on laser incident trends.

Please do not send information that is classified or in regard a specific laser event.

After you have read the Consent Form, please set aside approximately 15-30 minutes to complete the survey. The survey may be returned to this e-mail address by either replying or sending the file attachment to kclark@usuhs.mil. If you have any questions, concerns or problems with the file attachment, please contact me at the above e-mail address or by phone at 301-295-9296 or DSN 295-9296. Thank you for your participation in this study.

Please return the survey no later than 5 March 2004.

V/R,

Krystyn R. Clark

Krystyn R. Clark, Capt, USAF, BSC  
USUHS/PMB  
4301 Jones Bridge Rd  
Bethesda, MD 20814

301-295-9296  
DSN 295-9296  
kclark@usuhs.mil

**APPENDIX C**  
**Informed Consent Information**  
**Uniformed Services University Protocol T087UK**  
**Principal Investigator: Capt Krystyn Clark, USAF, BSC**

This questionnaire is part of a research study designed to determine the best information for laser incident assessments. This information may help to identify people at risk and also help to direct future efforts for laser incident assessment and prevention. The study is being conducted by the Uniformed Services University, Department of Preventive Medicine and Biometrics, located in Bethesda, Maryland.

You are being asked to participate in this survey because you are a Department of Defense (DoD) employee (civilian, active duty, reserve, etc.) or DoD contractor who has been identified as an individual who is knowledgeable about information that should be collected in the event of a laser incident. You were identified as a knowledgeable person on laser injuries by a specialty leader, other person with expertise in laser operations, studies, or medical evaluation, or because you may work closely in laser incidents due to the nature of your field (i.e. accident investigation or injury evaluation). Approximately 60 DoD employees may take this survey, which will be sent via email.

In the survey, you will be asked for your opinion on health and safety information that should be collected for laser incidents. You will be asked to complete a minimum of three questionnaires that should take no more than 30 minutes each to complete, with the initial survey requiring the most time. This survey consists of open-ended questions about laser incident data that you think should be collected for a central database. The second and subsequent surveys will expand on responses by pooling all responses anonymously and resending them until a consensus is reached. Participants will then rank responses by order of importance as the final round. Information given for purposes of this study has the potential to enhance the health and safety of Air Force personnel due to improved and complete data collection of laser incidents.

Participation in this study is voluntary and anonymous. You may refuse to participate in this study or discontinue participation at any time. There are no consequences to you for refusing to participate.

**Confidentiality**

**The information you provide will not be linked to you in any way.** The information you provide will not be associated with your name, email address, or any other unique personal information. Access to survey responses collected in this study is restricted to members of the study staff and officials of the Uniformed Services University, who may review study files as part of their duties to protect human participants in research. **All information will be kept confidential to the full extent provided by law.** At the end of the study all personal identifying information, such as your name and email address, will be removed from the study files and destroyed.

### **Benefits and Risks of Participation in this Study**

There are no direct benefits to you for participating in this study. Your responses may help scientists and the DoD to collect the best, most useful information about laser incidents. The results of this study will be shared with others through publication in the scientific literature and in other publications. As a health or safety professional, this study provides an opportunity for you to provide input on how laser incident information is collected. Reports from this study may better characterize what common factors are associated with laser injuries and contribute to new ideas for personnel protection that will lead to injury reduction.

### **If you have questions about this study**

If you have questions about this study you may contact the study Principal Investigator, Capt. Krystyn Clark, M.S., USAF, a Health Physicist at the Uniformed Services University, at [kclark@usuhs.mil](mailto:kclark@usuhs.mil) or via phone at 301-295-9296. If you have any questions about your rights as a participant in this study you may contact the Director, Human Research Protections Program, Uniformed Services University, at 301-295-3303.

Completion of the questionnaire indicates your consent for inclusion in this laser incident study.

**APPENDIX D**  
**Delphi Laser Survey**  
**Uniformed Services University Protocol T087UK**  
**Principal Investigator: Capt Krystyn Clark, USAF, BSC**

**Background**

The number of lasers used in the military has increased. However, it is uncertain that all injuries are properly reported, or that the correct information is being collected when they are reported. In order to identify patterns of injuries, best evaluation methods, and successful techniques for protection, it is important to collect quality data in a standard format for all reports. The first step in this process is to identify essential information that should be collected to populate a database that will be created for purposes of laser incident studies. Besides an injury, an incident may include equipment malfunction, laser light visualization without injury, a near miss situation, or any other undesired event involving a laser system that could contribute to understanding laser injury risks leading to better response by health care providers and safety professionals.

**The Survey Instrument**

The Delphi technique is a useful tool when it is geographically difficult to bring professionals together to reach a consensus. Using e-mail, individuals are asked to answer questions about laser incident reporting. Each individual submits a list of the requested information based on professional knowledge of laser hazards and effects. Once all the responses are in, they will be combined into a single anonymous list of all responses. This new list will be returned to the respondents who will clarify or add items to the list. This process continues until a consensus is reached and new items have been exhausted for all information that should be collected for laser incidents. This usually occurs in 2-3 rounds. A final e-mail will be sent to participants asking each item to be ranked by order of importance. Again, participants will return their rank-ordered responses, which will be used to determine what will be included on the data collection form and entered into the laser incident database in the future. The more information provided during the survey process, the more useful the database will be for future studies of laser incident risk factors, injury prevention strategies, and medical evaluation options.

**Instructions**

Please read the instructions for each item carefully before you answer. There are no right or wrong answers to the questions, only your professional opinions. Questions can be answered by providing a list of essential laser incident database fields or a brief description of pertinent information that you feel should be collected for laser incident documentation. Although you can choose not to answer questions, it limits the helpfulness of the questionnaire so please provide as much information as you can.

Please do not send information that is classified or in regard a specific laser event. Submit only the *type* of data that should be included in a laser incident database, not data from an actual incident.

### Questions

Please list as many items as possible about a laser incident that should be collected for each of the following categories:

1. Demographic data (information about the person involved in the incident)
2. Laser system characteristics (information specific to the laser involved)
3. Information about the event (specific information about circumstances of the event)
4. Medical information (exams, outcome, follow-up)
5. Other information that does not fit into the other categories

\_\_\_ I do not wish to include my responses in this survey because I have little experience/expertise regarding laser incidents

\_\_\_ I do not wish to participate, please withdraw my name from the survey

Please remember that all information submitted for this study is confidential including your decision to decline participation.

# APPENDIX E

LASER INCIDENT REPORTING FORM			
Personal Information			
Name (Last, First, MI, Suffix)		Unique Identifier (leave blank):	
Date of Birth (yyyy/mm/dd):	Sex <input type="checkbox"/> Male <input type="checkbox"/> Female	Today's Date (yyyy/mm/dd):	
Current Status (check one): <input type="checkbox"/> Active Duty <input type="checkbox"/> Reserve <input type="checkbox"/> National Guard <input type="checkbox"/> Consultant <input type="checkbox"/> DoD Civilian (GS) <input type="checkbox"/> Contractor <input type="checkbox"/> Other (specify) _____		Grade/Rank	Branch of Service
Squadron (or equivalent)	Current job title	Job code (AFSC/MOS/GS/etc):	
Occupational history working with lasers (list past jobs):		Contractor Company Name:	
Laser System Information			
Manufacturer name:	Model/serial numbers (laser plus any components):	System name/designator (i.e. LANTIRN):	
Wavelength (in nm):	<input type="checkbox"/> Pulse <input type="checkbox"/> Continuous Wave <input type="checkbox"/> Unknown <input type="checkbox"/> Other (specify): _____	If Pulsed: (in seconds) Pulse Width: Pulse Repetition Frequency:	
Peak Power/Energy (W/cm <sup>2</sup> or J/cm <sup>2</sup> )		Average Power/Energy (W/cm <sup>2</sup> or J/cm <sup>2</sup> )	
Secondary wavelength(s) <input type="checkbox"/> Yes <input type="checkbox"/> No List:		If secondary wavelength(s) (W/cm <sup>2</sup> or J/cm <sup>2</sup> ) Power: Energy:	
ANSI class: <input type="checkbox"/> Class I <input type="checkbox"/> Class II <input type="checkbox"/> Class IIIa		<input type="checkbox"/> Class IIb <input type="checkbox"/> Class IV <input type="checkbox"/> Unknown <input type="checkbox"/> Military Exempt	
Controls in place during incident (check all that apply): <input type="checkbox"/> Key control <input type="checkbox"/> Viewing portals <input type="checkbox"/> Controlled area <input type="checkbox"/> Interlocks <input type="checkbox"/> Access panels <input type="checkbox"/> Beam stop or attenuator <input type="checkbox"/> External optics		<input type="checkbox"/> Limited beam paths <input type="checkbox"/> Remote <input type="checkbox"/> Emission delay <input type="checkbox"/> Protective housing <input type="checkbox"/> Engineering control over-rides <input type="checkbox"/> None <input type="checkbox"/> Unknown Warning system: <input type="checkbox"/> Lights <input type="checkbox"/> Signs <input type="checkbox"/> Audible alarm <input type="checkbox"/> Other: _____ _____ _____ _____	
Were any safety procedures by-passed? <input type="checkbox"/> Yes <input type="checkbox"/> No		Caused by laser and/or safety equipment failure? <input type="checkbox"/> Yes <input type="checkbox"/> No	



Beam Exposure (check all that apply): <input type="checkbox"/> Direct Beam <input type="checkbox"/> Reflection (shiny surface) <input type="checkbox"/> Refraction (dull surface) <input type="checkbox"/> Unknown		If known, list surface that last directed the beam to the expected overexposure area (i.e. mirror, jewelry):	
Personal protective equipment (PPE) and/or laser eye protection (LEP) was (check all that apply): <input type="checkbox"/> Available <input type="checkbox"/> Appropriate <input type="checkbox"/> Worn during <input type="checkbox"/> Removed <input type="checkbox"/> Not applicable <input type="checkbox"/> Unknown		If worn, list type of PPE worn and Optical Density (OD) of LEP:	
Written guidance in place? (i.e. Standard Operating Procedures or Operational Instructions) <input type="checkbox"/> Yes <input type="checkbox"/> No		List general level of laser training: <input type="checkbox"/> User-only training <input type="checkbox"/> Laser safety professional <input type="checkbox"/> Certified Laser Safety Officer <input type="checkbox"/> None <input type="checkbox"/> Other: _____	
Surgical laser only, effective range:			
<b>Details of the Event</b>			
Duration of exposure: _____ seconds		What were your indications of exposure? (i.e. bright light, glare, noise, equipment degradation) (If applicable, describe the sensors and their sensitive wavelength ranges)	
Was the beam <input type="checkbox"/> Focused <input type="checkbox"/> Scattered		Where were you looking in respect to the light? <input type="checkbox"/> Direct <input type="checkbox"/> Above <input type="checkbox"/> Below <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Other: _____	
What was between the light source and your eyes: <input type="checkbox"/> Windscreen <input type="checkbox"/> Glasses <input type="checkbox"/> Visors <input type="checkbox"/> Contacts <input type="checkbox"/> Head-up display <input type="checkbox"/> Binoculars <input type="checkbox"/> Filters <input type="checkbox"/> NVG <input type="checkbox"/> Goggles <input type="checkbox"/> Nothing <input type="checkbox"/> Other: _____			
List type, magnification, material (i.e. 2X binoculars, prescription glasses, windscreen):			
Were any of the above damaged or caused to malfunction by the light? <input type="checkbox"/> Yes <input type="checkbox"/> No      List: _____			
Were sensors affected? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown		Event type: <input type="checkbox"/> Property damage <input type="checkbox"/> Injury <input type="checkbox"/> Non-injury <input type="checkbox"/> High Accident Potential (HAP) event (i.e. military airport) <input type="checkbox"/> Other (list): _____	
Did the laser appear to be a <input type="checkbox"/> Classroom pointer <input type="checkbox"/> Rangefinder <input type="checkbox"/> Survey tool <input type="checkbox"/> Weapon <input type="checkbox"/> Unknown <input type="checkbox"/> Other (list): _____		Event caused by: <input type="checkbox"/> Enemy forces <input type="checkbox"/> 'Friendly' fire <input type="checkbox"/> Not applicable	Was the event self-inflicted? <input type="checkbox"/> Yes <input type="checkbox"/> No
Did the laser impact your ability to complete your mission? <input type="checkbox"/> Yes <input type="checkbox"/> No		How far away was the laser light source? _____ feet	Was it moving? <input type="checkbox"/> Yes <input type="checkbox"/> No
Event scenario: <input type="checkbox"/> Wartime Operations <input type="checkbox"/> Recreational <input type="checkbox"/> Exercise/Training <input type="checkbox"/> Research <input type="checkbox"/> Routine work <input type="checkbox"/> Assault <input type="checkbox"/> Maintenance <input type="checkbox"/> Other (list): _____		Geographic location of event: <input type="checkbox"/> Land <input type="checkbox"/> Sea <input type="checkbox"/> Air	
Specific location of individual <input type="checkbox"/> Ship <input type="checkbox"/> Bunker <input type="checkbox"/> Tank <input type="checkbox"/> Medical facility <input type="checkbox"/> Range <input type="checkbox"/> Combat area <input type="checkbox"/> Lab <input type="checkbox"/> Flight line <input type="checkbox"/> Aircraft <input type="checkbox"/> Other building <input type="checkbox"/> Other: _____			

Event location was: <input type="checkbox"/> Indoors <input type="checkbox"/> Outdoors	If unidentified laser, from what source/platform did the laser emanate? <input type="checkbox"/> Tank <input type="checkbox"/> Airplane <input type="checkbox"/> Helicopter <input type="checkbox"/> Other (list): _____
Describe area (source) where beam originated <input type="checkbox"/> Buildings <input type="checkbox"/> Barren area <input type="checkbox"/> Airborne <input type="checkbox"/> People <input type="checkbox"/> Forest <input type="checkbox"/> Desert <input type="checkbox"/> Industrial/ Occupational <input type="checkbox"/> Other (list): _____	
<i>Aircraft exposure only</i>	
Did it appear to track the aircraft? <input type="checkbox"/> Yes <input type="checkbox"/> No	Were evasive tactics successful? <input type="checkbox"/> Yes <input type="checkbox"/> No
<b>Medical Data</b>	
<b><i>Pre-Exposure Information</i></b>	
Visual acuity before incident OD 20/____ OS 20/____	Previous laser exposure: <input type="checkbox"/> Yes <input type="checkbox"/> No If yes, method of exposure: _____ <input type="checkbox"/> Medical <input type="checkbox"/> Occupational <input type="checkbox"/> Recreational
Pre-employment laser eye exam given: <input type="checkbox"/> Yes <input type="checkbox"/> No Date of exam(month/year): _____ Location: _____ Results of exam: _____	
<b><i>General Post Exposure History (Skin and/or Eye)</i></b>	
Part of body: <input type="checkbox"/> Eyes: <input type="checkbox"/> Right <input type="checkbox"/> Left <input type="checkbox"/> Both  <input type="checkbox"/> Skin Location: _____	Signs/Symptoms (Check all that apply): <input type="checkbox"/> Visual changes <input type="checkbox"/> Reddening <input type="checkbox"/> Warming <input type="checkbox"/> Irritation <input type="checkbox"/> Burn <input type="checkbox"/> Pain  Rank on scale of 0-10: 0 = no pain, 10 = most severe) <input type="checkbox"/> 0 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5 <input type="checkbox"/> 6 <input type="checkbox"/> 7 <input type="checkbox"/> 8 <input type="checkbox"/> 9 <input type="checkbox"/> 10  Signs/Symptoms were: <input type="checkbox"/> Immediate <input type="checkbox"/> Delayed
Permanent damage? <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Unknown	
Any lingering signs or symptoms? <input type="checkbox"/> Yes <input type="checkbox"/> No Specify _____ Is (are) the symptom (s)? <input type="checkbox"/> Continuous <input type="checkbox"/> Intermittent How long? <input type="checkbox"/> Minutes <input type="checkbox"/> Hours <input type="checkbox"/> Days <input type="checkbox"/> Months	
Visual acuity testing done in the field prior to definitive care: <input type="checkbox"/> Yes <input type="checkbox"/> No Results: OD 20/____ OS 20/____ Type of exam (i.e. wall chart): _____ List other field exams/results (i.e. Amsler Grid): _____	
Patient referred for full ophthalmologic exam? <input type="checkbox"/> Yes <input type="checkbox"/> No	
What treatment/medication was administered to laser patient? How soon after exposure?	
What did the patient do immediately after the incident (i.e. did he/she rub the eye/skin)?	
<i>Incident History (Eye Specific):</i>	
Comprehensive ophthalmologic exam given post exposure?: <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Partial	

Did laser affect vision? <input type="checkbox"/> Yes <input type="checkbox"/> No If yes: <input type="checkbox"/> Dazzle <input type="checkbox"/> Afterimages <input type="checkbox"/> Blurring <input type="checkbox"/> Black spots <input type="checkbox"/> Other (specify): _____		Nature of exposure: <input type="checkbox"/> Glare <input type="checkbox"/> Blinding <input type="checkbox"/> Visible light <input type="checkbox"/> Other (specify): _____	
Was laser sufficiently bright to cause patient to squint or look away? <input type="checkbox"/> Yes <input type="checkbox"/> No		How much of patient's field of view was affected? <input type="checkbox"/> 0-25% <input type="checkbox"/> 25-50% <input type="checkbox"/> 50-75% <input type="checkbox"/> 75-100%	
Related eye injury (i.e. corneal or skin burns, blunt/sharp trauma, foreign body injury) <input type="checkbox"/> Yes <input type="checkbox"/> No      Location: _____ Type: _____			
How long until you were able to see normally again? <input type="checkbox"/> Minutes <input type="checkbox"/> Hours <input type="checkbox"/> Days <input type="checkbox"/> Months		Location of injury in retina: <input type="checkbox"/> Macular <input type="checkbox"/> Extra-macular	
<i>Post Exposure Physical Examination (Eye):</i>			
Visual acuity: Uncorrected: OD 20/____ Corrected: OD 20/____ Uncorrected: OS 20/____ Corrected: OS 20/____ Type of exam (i.e. wall chart): _____		Amsler Grid <input type="checkbox"/> Yes <input type="checkbox"/> No Result: _____	
Color vision <input type="checkbox"/> Yes <input type="checkbox"/> No (Ishihara Test) Result: _____		Fundus photograph?: Undilated <input type="checkbox"/> Yes <input type="checkbox"/> No      Dilated <input type="checkbox"/> Yes <input type="checkbox"/> No Current Photograph Location? Specify _____	
Visible lesion <input type="checkbox"/> Yes <input type="checkbox"/> No	Macular lesion <input type="checkbox"/> Yes <input type="checkbox"/> No	Hemorrhagic lesion <input type="checkbox"/> Yes <input type="checkbox"/> No	
Slit lamp exam? (UV, Mid/Far IR) (particularly corneal, iris and lens status) <input type="checkbox"/> Yes <input type="checkbox"/> No Gross Findings: _____ _____	Posterior segment and retinal exam? <input type="checkbox"/> Yes <input type="checkbox"/> No Gross Findings: _____ _____	Status and appearance of the fellow eye? (including retina) <input type="checkbox"/> Yes <input type="checkbox"/> No Gross Findings: _____ _____	
<i>Follow-up Eye Examinations:</i>			
Post-incident visual acuity at 30 days OD 20/____ OS 20/____			
Exam Type	3-month visit	6-month visit	____-month visit
Visual acuity (OD/OS)	<input type="checkbox"/> Yes <input type="checkbox"/> No 20/____ 20/____	<input type="checkbox"/> Yes <input type="checkbox"/> No 20/____ 20/____	<input type="checkbox"/> Yes <input type="checkbox"/> No 20/____ 20/____
Amsler grid	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____
Retinal exams	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____
Digital photos	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____
Fluorescein angiogram	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____	<input type="checkbox"/> Yes <input type="checkbox"/> No Results: _____

## APPENDIX F

Lower Limit of Detection (LLD) Used to Calculate Minimum Number of Laser Incidents Required to Observe an Increase in Laser Injuries with 95% Confidence (Knoll 2000)

Number of events detected –  $N_D$

Number of background events –  $N_B$

Assumptions:  $N_D / N_B \ll 1$ ,  $\sigma_{NB} =$

Find  $N_D$  as a function of  $\sigma_{NB}$

1 standard deviation (SD) =  $1.645 = 68\%$  of all samples deviate from the true mean by less than one value of the SD; mean  $\pm 1.645\sigma$  is 90%, but 95% when looking only at positive deviations from the mean, negative values indicate no trend is present.

Type I Error:  $\alpha = 0.05$

Type II Error:  $\beta = 0.05$

The LLD equation  $= 4.1653 \sigma_{NB} + 2.706$  is derived from a Binomial Expansion of the following:

With events present is present  $\sigma_{ND} = \sqrt{(2N_B + N_D)}$

$$\sigma_{ND} = (2N_B + N_D)^{1/2} = (2N_B)^{1/2} [(2N_B/2N_B) + (N_D/2N_B)]^{1/2}$$

$$\sigma_{ND} = (2N_B)^{1/2} [1 + (N_D/2N_B)]^{1/2}$$

Using a binomial expansion of  $[1 + (N_D/2N_B)]^{1/2}$ :

$$(1 + (N_D/2N_B))^{1/2} = 1 + (1/2)(N_D/2N_B) - (1/8)(N_D/2N_B)^2 + (1/16)(N_D/2N_B)^3 - (5/128)(N_D/2N_B)^4 + \dots$$

Because  $N_D \ll N_B$ ,  $(N_D/N_B)^n \ll (N_D/N_B)^3 \ll (N_D/N_B)^2 \ll N_D/N_B \ll 1$ ,

A good approximation is to delete all terms higher than the linear term in the expansion because all following terms are orders of magnitude smaller.

Therefore,  $(2N_B)^{1/2} [1 + (N_D/2N_B)]^{1/2}$

is approximately equal to

$$\sigma_{ND} = (2N_B)^{1/2} [1 + (N_D/4N_B)]$$

$$\sigma_{ND} = (2N_B)^{1/2} + [(2N_B)^{1/2}/4N_B] N_D$$

$$[(2N_D)^{1/2}/4N_B] N_D = \sigma_{ND} - (2N_B)^{1/2}$$

$$N_D = [4N_B / (2N_B)^{1/2}] [\sigma_{ND} - (2N_B)^{1/2}], \sigma_{ND} = (N_B)^{1/2}$$

$N_D = [(4 \sigma_{NB})^2 / (2)^{1/2} \sigma_{NB}] (\sigma_{ND} - (2)^{1/2} \sigma_{NB})^{1/2}$  a crude background approximation of initial counts

$$N_D = 4.653 \sigma_{NB}$$

To add refinement to the relationship between  $\sigma_{ND}$  and  $\sigma_{NB}$ , a better approximation is  $N_D = (4 \sigma_{NB})^2 [(\sigma_{ND} - (2)^{1/2} \sigma_{NB})]$

$$4.1653 \sigma_{NB} = (4 \sigma_{NB})^2 [(\sigma_{ND} - (2)^{1/2} \sigma_{NB})], \text{ solve for } \sigma_{ND}$$

$$\sigma_{ND} = (2)^{1/2} \sigma_{NB} + 1.645$$

For a 95% Confidence Level, must have  $N_D = L_C + 1.645 \sigma_{ND}$

Substituting:  $L_C = 2.326 \sigma_{NB}$  and  $\sigma_{ND} = (2)^{1/2} \sigma_{NB} + 1.645$

$N_D = 4.1653 \sigma_{NB} + 2.706$
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**$N_D$  as defined above can be interpreted as the minimum number of events needed to establish an increase in incident rate with 95% confidence.**

## **APPENDIX G**

### **NAIC Checklists**

#### **LASER INCIDENT CHECKLIST - AIRCREW**

- A. DATE AND TIME OF INCIDENT AND LOCAL TIME USING 24-HOUR CLOCK. ALSO GIVE THE GREENWICH MEAN TIME DATE AND TIME (Z). (EXAMPLE: 20021130/2020L;20021201/0220Z).
- B. TYPE OF AIRCRAFT FLOWN (PROVIDE MISSION-DESIGN-SERIES DESIGNATOR AND TYPE. EXAMPLE: F-16CJ, F-15E, ETC) INCLUDE ALL AIRCRAFT IN MISSION GROUP. WHAT WERE THE ORIENTATIONS OF OTHER AIRCRAFT FLYING WITH YOURS AT THE TIME OF THE MISHAP
- C. GEOGRAPHICAL LOCATION OF MISHAP (COUNTRY, REGION, GEOCOORDS: GIVE BEST KNOWN LATITUDE AND LONGITUDE OF MISHAP IN DEGREES AND MINUTES TO WITHIN 2 DECIMAL PLACES. ALSO, DESCRIBE LOCATION/TERRAIN (EXAMPLE: RURAL, MOUNTAINOUS, CITY, ETC)
- D. DESCRIBE YOUR TASK IN AIRCRAFT (LOAD MASTER, PILOT, ETC) AND WHAT WERE YOU DOING AT THE TIME OF THE EVENT
- E. ALTITUDE/SPEED/HEADING OF AIRCRAFT
- F. AIRCRAFT TAIL NUMBER AND SERIAL NUMBER. ALSO PROVIDE FOR OTHER AIRCRAFT FLYING SAME MISSION
- G. ORGANIZATION TO WHICH AIRCRAFT ARE ASSIGNED (MAJCOM, NAF, WING, SQUADRON, BASE)
- H. WHAT LASER/ELECTRO-OPTICAL EQUIPMENT WERE USED TO DURING MISSION (EXAMPLE, AIR COMMANDER'S POINTER (ACP), LASER RANGEFINDERS, NVGS, TV SENSORS, FLIRS, LANTIRN LASER DESIGNATOR, LITENING LASER DESIGNATOR, ETC)
- I. WAS ANY EQUIPMENT JAMMED/DAMAGED DURING MISSION. DESCRIBE IN DETAIL (AMOUNT OF FOV OBSCURED, DURATION, PERMANENT DAMAGE, CURRENT HEALTH OF SENSOR AFTER MISSION, ETC) FOR ANY MISHAP INVOLVING LANTIRN, LITENING, MISSILES, ETC, INCLUDE INFORMATION ON THAT EQUIPMENT. BE SURE TO SPECIFY ACCOUNTABLE MAJCOM/WING/SQUADRON FOR EQUIPMENT.
- J. ATMOSPHERIC CONDITIONS (CLEAR/CLOUDY, WEATHER, ETC) INCLUDE TIME OF DAY, LEVEL OF MOONLIGHT
- K. DESCRIPTION OF EVENT
  - 1) LOCATION OF LASER AND DESCRIPTION OF LASER PLATFORM (TRIPOD, TRUCK-MOUNTED, AIRCRAFT-MOUNTED, HANDHELD, ETC) INCLUDE GEOCOORDS AND PHYSICAL DESCRIPTION OF AREA

- 2) DESCRIBE ALL OTHER ACTIVITY (GROUND- OR AIR-BASED) THAT WAS ONGOING DURING THE EVENT (US, ALLIES, FOREIGN)
  - 3) DURATION OF EVENT
  - 4) COLOR OF LASER LIGHT
  - 5) RANGE BETWEEN LASER SOURCE AND AIRCRAFT
  - 6) LASER PULSED OR CONTINUOUS. IF PULSED, WHAT WAS THE PULSE RATE?
  - 7) WAS LASER SOURCE STATIONARY DURING THE ENTIRE EVENT
  - 8) WAS LASER DIRECTED ONTO THE AIRCRAFT? DID IT APPEAR TO TRACK THE AIRCRAFT? DID YOU MANEUVER? WAS THE BEAM ABLE TO CONTINUE TRACKING THROUGH THE MANEUVERS?
  - 9) HOW LARGE WAS THE LASER SPOT ON THE AIRCRAFT (DIME, QUARTER, ETC)
  - 10) WHAT ACTION DID YOU TAKE IN RESPONSE TO LASER?
  - 11) DID THE LASER IMPACT YOUR ABILITY TO COMPLETE YOUR MISSION?
  - 12) DID ANY OTHER INSTRUMENTS INDICATE THAT A LASER EVENT HAD OCCURRED?
- L. WAS VISION AFFECTED BY LASER? (DAZZLE, AFTERIMAGES, BLACK SPOTS, BLURRING, ETC)
- M. HOW LONG DID THIS PROBLEM LAST?
- N. HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
- O. WERE BOTH EYES AFFECTED IN SAME WAY? TO SAME EXTENT?
- P. WAS LASER SUFFICIENTLY BRIGHT TO CAUSE YOU TO LOOK AWAY? SQUINT? WAS THE LIGHT PAINFUL TO LOOK AT? DID THE PAIN PERSIST AFTER THE EVENT? DID YOU NOTICE ANY REDDENING OR BURNS ON YOUR SKIN?
- Q. WAS YOUR VISION AFFECTED?
- 1) HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
  - 2) DID THE COLOR OF TARGETS OR INSTRUMENTS CHANGE?
  - 3) DID YOUR VISION CONTINUE TO BE AFFECTED WHEN THE LASER WAS TURNED OFF? DESCRIBE IN DETAIL
- R. DID YOU SEEK OUT MEDICAL ATTENTION FOLLOWING INCIDENT? WHICH UNIT OR ORGANIZATION? WHAT WAS THE DIAGNOSIS?
- S. IF YOU HAVE HAD THE AMSLER GRID TEST, DESCRIBE IN DETAIL ANY CHANGES YOU OR THE DOCTOR NOTED.
- T. WERE YOU USING NIGHT VISION GOGGLES, BINOCULARS, LASER PROTECTION, ETC. DESCRIBE IN DETAIL WHAT WAS BETWEEN YOU AND YOUR CANOPY/WINDSCREEN?
- U. DESCRIBE YOUR VISUAL ABILITY BEFORE EVENT (CORRECTIVE LENS, MEDICATION, ETC)

***Provide Classifying authority and downgrading information***

**LASER INCIDENT CHECKLIST - GROUND CREW**

- A. DATE AND TIME OF INCIDENT AND LOCAL TIME USING 24-HOUR CLOCK. ALSO GIVE THE GREENWICH MEAN TIME DATE AND TIME (Z). (EXAMPLE: 20021130/2020L;20021201/0220Z).
- B. TYPE OF YOUR VEHICLE INVOLVED (PROVIDE MISSION-DESIGN-SERIES DESIGNATOR AND TYPE. EXAMPLE: BRADLEY, HUMMV, ETC) INCLUDE ALL VEHICLES IN MISSION GROUP. WHAT WERE THE ORIENTATIONS OF OTHER VEHICLES RELATIVE TO YOURS AT THE TIME OF THE MISHAP
- C. GEOGRAPHICAL LOCATION OF MISHAP (COUNTRY, REGION, GEOCOORDS: GIVE BEST KNOWN LATITUDE AND LONGITUDE OF MISHAP IN DEGREES AND MINUTES TO WITHIN 2 DECIMAL PLACES. ALSO, DESCRIBE LOCATION/TERRAIN (EXAMPLE: RURAL, MOUNTAINOUS, CITY, ETC)
- D. DESCRIBE YOUR TASK (DRIVER, GUNNER, ETC) AND WHAT WERE YOU DOING AT THE TIME OF THE EVENT
- E. SPEED/HEADING OF VEHICLE
- F. VEHICLE IDENTIFICATION NUMBER AND SERIAL NUMBER. ALSO PROVIDE FOR OTHER VEHICLES ON SAME MISSION
- G. ORGANIZATION TO WHICH VEHICLES ARE ASSIGNED (MAJCOM, BATTALION, UNIT, SQUADRON, BASE)
- H. WHAT LASER/ELECTRO-OPTICAL EQUIPMENT WERE USED TO DURING MISSION (EXAMPLE, LASER RANGEFINDERS, NVGS, TV SENSORS, FLIRS, LASER DESIGNATORS, ETC)
- I. WAS ANY EQUIPMENT JAMMED/DAMAGED DURING MISSION. DESCRIBE IN DETAIL (AMOUNT OF FOV OBSCURED, DURATION, PERMANENT DAMAGE, CURRENT HEALTH OF SENSOR AFTER MISSION, ETC) FOR ANY MISHAP INVOLVING SENSORS, INCLUDE INFORMATION ON THAT EQUIPMENT. BE SURE TO SPECIFY ACCOUNTABLE MAJCOM/UNIT/SQUADRON FOR EQUIPMENT.
- L. ATMOSPHERIC CONDITIONS (CLEAR/CLOUDY, WEATHER, ETC) INCLUDE TIME OF DAY, LEVEL OF MOONLIGHT
- M. DESCRIPTION OF EVENT
  - 13) LOCATION OF LASER AND DESCRIPTION OF LASER PLATFORM (TRIPOD, TRUCK-MOUNTED, AIRCRAFT-MOUNTED, HANDHELD, ETC) INCLUDE GEOCOORDS AND PHYSICAL DESCRIPTION OF AREA



- 14) DESCRIBE ALL OTHER ACTIVITY (GROUND- OR AIR-BASED) THAT WAS ONGOING DURING THE EVENT (US, ALLIES, FOREIGN)
  - 15) DURATION OF EVENT
  - 16) COLOR OF LASER LIGHT
  - 17) RANGE BETWEEN LASER SOURCE AND YOUR VEHICLE
  - 18) WAS THE LASER PULSED OR CONTINUOUS. IF PULSED, WHAT WAS THE PULSE RATE?
  - 19) WAS LASER SOURCE STATIONARY DURING THE ENTIRE EVENT
  - 20) WAS LASER DIRECTED AT YOUR VEHICLE? DID IT APPEAR TO TRACK YOUR VEHICLE? DID YOU MANEUVER? WAS THE BEAM ABLE TO CONTINUE TRACKING THROUGH THE MANEUVERS?
  - 21) HOW LARGE WAS THE LASER SPOT ON THE VEHICLE (DIME, QUARTER, ETC)
  - 22) WHAT ACTION DID YOU TAKE IN RESPONSE TO LASER?
  - 23) DID THE LASER IMPACT YOUR ABILITY TO COMPLETE YOUR MISSION?
  - 24) DID ANY OTHER INSTRUMENTS INDICATE THAT A LASER EVENT HAD OCCURRED?
- N. WAS VISION AFFECTED BY LASER? (DAZZLE, AFTERIMAGES, BLACK SPOTS, BLURRING, ETC)
- O. HOW LONG DID THIS PROBLEM LAST?
- P. HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
- Q. WERE BOTH EYES AFFECTED IN SAME WAY? TO SAME EXTENT?
- R. WAS LASER SUFFICIENTLY BRIGHT TO CAUSE YOU TO LOOK AWAY? SQUINT? WAS THE LIGHT PAINFUL TO LOOK AT? DID THE PAIN PERSIST AFTER THE EVENT? DID YOU NOTICE ANY REDDENING OR BURNS ON YOUR SKIN?
- S. WAS YOUR VISION AFFECTED?
- 4) HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
  - 5) DID THE COLOR OF TARGETS OR INSTRUMENTS CHANGE?
  - 6) DID YOUR VISION CONTINUE TO BE AFFECTED WHEN THE LASER WAS TURNED OFF? DESCRIBE IN DETAIL
- T. DID YOU SEEK OUT MEDICAL ATTENTION FOLLOWING INCIDENT? WHICH UNIT OR ORGANIZATION? WHAT WAS THE DIAGNOSIS?
- U. IF YOU HAVE HAD THE AMSLER GRID TEST, DESCRIBE IN DETAIL ANY CHANGES YOU OR THE DOCTOR NOTED.
- V. WERE YOU USING NIGHT VISION GOGGLES, BINOCULARS, LASER PROTECTION, ETC. DESCRIBE IN DETAIL WHAT WAS BETWEEN

- YOU AND THE LASER SOURCE (I.E. GLASSES, LASER EYE PROTECTION, WINDOWS, ETC?)
- W. DESCRIBE YOUR VISUAL ABILITY BEFORE EVENT (CORRECTIVE LENS, MEDICATION, ETC)

***Provide Classifying authority and downgrading information***

**LASER INCIDENT CHECKLIST - SAILORS**

- A. DATE AND TIME OF INCIDENT AND LOCAL TIME USING 24-HOUR CLOCK. ALSO GIVE THE GREENWICH MEAN TIME DATE AND TIME (Z). (EXAMPLE: 20021130/2020L;20021201/0220Z).
- B. TYPE OF YOUR SHIP OR AMPHIBIOUS VEHICLE INVOLVED (PROVIDE MISSION-DESIGN-SERIES DESIGNATOR AND TYPE. EXAMPLE: AIRCRAFT CARRIER, CRUISERS, ETC) INCLUDE ALL PLATFORMS IN MISSION GROUP. WHAT WERE THE ORIENTATIONS OF OTHER PLATFORMS RELATIVE TO YOURS AT THE TIME OF THE MISHAP
- C. GEOGRAPHICAL LOCATION OF MISHAP (COUNTRY, REGION, GEOCOORDS: GIVE BEST KNOWN LATITUDE AND LONGITUDE OF MISHAP IN DEGREES AND MINUTES TO WITHIN 2 DECIMAL PLACES. ALSO, DESCRIBE LOCATION/TERRAIN (EXAMPLE: RURAL, MOUNTAINOUS, CITY, ETC)
- D. DESCRIBE YOUR TASK (OBSERVERS, GUNNERS, ETC) AND WHAT WERE YOU DOING AT THE TIME OF THE EVENT
- E. SPEED/HEADING OF VEHICLE
- F. PLATFORM NAME AND SERIAL NUMBER. ALSO PROVIDE FOR OTHER PLATFORMS ON SAME MISSION
- G. ORGANIZATION TO WHICH PLATFORMS ARE ASSIGNED (MAJCOM, FLEET, CARRIER BATTLEGROUP, BASE)
- H. WHAT LASER/ELECTRO-OPTICAL EQUIPMENT WERE USED TO DURING MISSION (EXAMPLE, LASER RANGEFINDERS, NVGS, TV SENSORS, FLIRS, LASER DESIGNATORS, ETC)
- I. WAS ANY EQUIPMENT JAMMED/DAMAGED DURING MISSION. DESCRIBE IN DETAIL (AMOUNT OF FOV OBSCURED, DURATION, PERMANENT DAMAGE, CURRENT HEALTH OF SENSOR AFTER MISSION, ETC) FOR ANY MISHAP INVOLVING SENSORS, INCLUDE INFORMATION ON THAT EQUIPMENT. BE SURE TO SPECIFY ACCOUNTABLE MAJCOM/FLEET/BATTLEGROUP FOR EQUIPMENT.
- J. ATMOSPHERIC CONDITIONS (CLEAR/CLOUDY, WEATHER, ETC) INCLUDE TIME OF DAY, LEVEL OF MOONLIGHT
- K. DESCRIPTION OF EVENT
  - 25) LOCATION OF LASER AND DESCRIPTION OF LASER PLATFORM (TRIPOD, TRUCK-MOUNTED, AIRCRAFT-

- MOUNTED, SHIP-MOUNTED, HANDHELD, ETC) INCLUDE GEOCOORDS AND PHYSICAL DESCRIPTION OF AREA
- 26) DESCRIBE ALL OTHER ACTIVITY (GROUND-, SHIP, OR AIR-BASED) THAT WAS ONGOING DURING THE EVENT (US, ALLIES, FOREIGN)
  - 27) DURATION OF EVENT
  - 28) COLOR OF LASER LIGHT
  - 29) RANGE BETWEEN LASER SOURCE AND YOUR VEHICLE
  - 30) WAS THE LASER PULSED OR CONTINUOUS. IF PULSED, WHAT WAS THE PULSE RATE?
  - 31) WAS LASER SOURCE STATIONARY DURING THE ENTIRE EVENT
  - 32) WAS LASER DIRECTED AT YOUR PLATFORM? DID IT APPEAR TO TRACK YOUR PLATFORM? DID YOU MANEUVER? WAS THE BEAM ABLE TO CONTINUE TRACKING THROUGH THE MANEUVERS?
  - 33) HOW LARGE WAS THE LASER SPOT ON THE VEHICLE (DIME, QUARTER, ETC)
  - 34) WHAT ACTION DID YOU TAKE IN RESPONSE TO LASER?
  - 35) DID THE LASER IMPACT YOUR ABILITY TO COMPLETE YOUR MISSION?
  - 36) DID ANY OTHER INSTRUMENTS INDICATE THAT A LASER EVENT HAD OCCURRED?
- L. WAS VISION AFFECTED BY LASER? (DAZZLE, AFTERIMAGES, BLACK SPOTS, BLURRING, ETC)
  - M. HOW LONG DID THIS PROBLEM LAST?
  - N. HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
  - O. WERE BOTH EYES AFFECTED IN SAME WAY? TO SAME EXTENT?
  - P. WAS LASER SUFFICIENTLY BRIGHT TO CAUSE YOU TO LOOK AWAY? SQUINT? WAS THE LIGHT PAINFUL TO LOOK AT? DID THE PAIN PERSIST AFTER THE EVENT? DID YOU NOTICE ANY REDDENING OR BURNS ON YOUR SKIN?
  - Q. WAS YOUR VISION AFFECTED?
    - 7) HOW MUCH OF YOUR FIELD OF VIEW WAS AFFECTED?
    - 8) DID THE COLOR OF TARGETS OR INSTRUMENTS CHANGE?
    - 9) DID YOUR VISION CONTINUE TO BE AFFECTED WHEN THE LASER WAS TURNED OFF? DESCRIBE IN DETAIL
  - R. DID YOU SEEK OUT MEDICAL ATTENTION FOLLOWING INCIDENT? WHICH UNIT OR ORGANIZATION? WHAT WAS THE DIAGNOSIS?
  - S. IF YOU HAVE HAD THE AMSLER GRID TEST, DESCRIBE IN DETAIL ANY CHANGES YOU OR THE DOCTOR NOTED.
  - T. WERE YOU USING NIGHT VISION GOGGLES, BINOCULARS, LASER PROTECTION, ETC. DESCRIBE IN DETAIL WHAT WAS BETWEEN

YOU AND THE LASER SOURCE (I.E. GLASSES, LASER EYE  
PROTECTION, WINDOWS, ETC?)

U. DESCRIBE YOUR VISUAL ABILITY BEFORE EVENT (CORRECTIVE  
LENS, MEDICATION, ETC)

***Provide Classifying authority and downgrading information***